G10 CMTS

Hardware Guide

Release 3.0

Juniper Networks, Inc.

1194 North Mathilda Avenue

Sunnyvale, CA 94089

USA

408-745-2000

www.juniper.net

Part Number: 530-009111-01, Revision 1

Writer: Jerry Isaac
Editor: Stella Hackell
Illustrations: Paul Gilman
Covers and template design: Edmonds Design

Revision History
14 May 2003—First Edition.

Table of Contents

About This Manual

Part 1
Product Overview

Chapter 1

Chapter 2

Part 2
Initial Installation

List of Figures

List of Tables

List of Tables

About This Manual

This chapter provides a high-level overview of the G10 CMTS Hardware Guide:

Objectives

This manual explains the hardware installation and basic troubleshooting for the G10 CMTS and your HFC plant. It contains procedures for preparing your site for CMTS installation, installing the hardware, starting up the CMTS, performing initial software configuration, and replacing field-replaceable units (FRUs). After completing the installation and basic configuration procedures covered in this manual, refer to the JUNOSg software configuration guides for information about further configuring the JUNOSg software.

To obtain additional information about Juniper Networks CMTSs—either corrections to information in this manual or information that might have been omitted from this manual—refer to the G10 CMTS hardware release notes.

To obtain the most current version of this manual, the most current version of the hardware release notes, and other Juniper Networks technical documentation, refer to the product documentation page on the Juniper Networks Web site, which is located at http://www.juniper.net.

To order printed copies of this manual or to order a documentation CD-ROM, which contains this manual, please contact your sales representative.

Audience

This manual is designed for network administrators who are installing and maintaining a G10 CMTS, or preparing a site for CMTS installation. It assumes that you have a broad understanding of HFC networks, networking principles, and network configuration. Any detailed discussion of these concepts is beyond the scope of this manual.

Document Organization

This manual is divided into several parts, each containing a category of information about the CMTS:

- Part 1, "Product Overview," provides an overview of the CMTS, describing its hardware components, the JUNOSg software, and the system architecture.
- Part 2, "Initial Installation," describes how to prepare and characterize your site for installing the CMTS, providing environmental and power supply specifications, rack and clearance requirements, and wiring and cabling guidelines. It also provides an overview of the installation process and lists safety precautions. Finally, it explains how to install the CMTS chassis and components and how to initially start the CMTS and configure the software.
- Part 3, "Troubleshooting and Maintenance," describes general troubleshooting procedures for the CMTS, cable modem operation, and the HFC plant, and explains how to track the source of problems. It also provides replacement procedures for some of the field-replaceable units.
- Part 4, "Appendixes," provides an appendix listing agency certifications, an appendix of DOCSIS radio frequency (RF) specifications, and an appendix listing various channel plans.
- Part 5, "Index," provides an index of the manual.

Related Documents

For information about configuring the software, including examples, see the following documents:

- *JUNOSg Software Configuration Guide: Getting Started and System Management*
- *JUNOSg Software Configuration Guide: Interfaces, Cable, Policy, and Routing and Routing Protocols*
- *JUNOSg Software Operational Mode Command Reference*

Documentation Conventions

This manual uses the following text conventions:

- CMTS and CMTS component labels are shown in a sans serif font. In the following example, ETHERNET is the label for the Ethernet management port on the CMTS:

    The 10/100-Mbps Ethernet RJ-45 connector is used for out-of-band management of the CMTS and is labeled ETHERNET.

- Statements, commands, filenames, directory names, IP addresses, and configuration hierarchy levels are shown in a sans serif font. In the following example, stub is a statement name and [edit protocols ospf area *area-id*] is a configuration hierarchy level:

    To configure a stub area, include the stub statement at the [edit protocols ospf area *area-id*] hierarchy level.

- In examples, text that you type literally is shown in bold. In the following example, you type the words **show chassis hardware**:

    For example, you can use the following command to get information about the source of an alarm condition:

    user@host> **show chassis hardware**

Notes, Cautions, and Warnings

Notes, cautions, and warnings are denoted by the following symbols:

Note

A note indicates information that might be helpful in a particular situation or that might otherwise be overlooked.

Caution

A caution indicates a situation that requires careful attention. Failure to observe a cautionary note could result in minor injury or discomfort to yourself, or serious damage to the CMTS.

Warning

A warning indicates a potentially dangerous situation. Failure to follow the guidelines in a warning could result in severe injury or death.

Contact Juniper Networks

For technical support, contact Juniper Networks at support@juniper.net, or at 1-888-314-JTAC (within the United States) or (+1) 408-745-9500 (from outside the United States).

Documentation Feedback

We are always interested in hearing from our customers. Please let us know what you like and do not like about the product documentation, and let us know of any suggestions you have for improving the documentation. Also, let us know if you find any mistakes in the documentation. Send your feedback and comments to techpubs-comments@juniper.net.

Part 1
Product Overview

Chapter 1
System Overview

This chapter provides an overview of the G10 CMTS.

System Description

The JUNOSg software runs on the G10 cable modem termination system (CMTS) and provides both IP routing (Layer 3) and IEEE 802.1 bridging (Layer 2), as well as software for interface, network, cable services, and chassis management. The G10 CMTS manages Internet voice and data. It functions as the interface between the service networks—Internet, Public Switched Telephone Network (PSTN)—and the *hybrid fiber/coax* (HFC) network of subscribers, as shown in Figure 1 on page 4. This is the "last mile" of broadband service, with the CMTS typically located in the cable headend or distribution hub. It is targeted at the following data and voice aggregation applications:

- Large CATV hub sites—DOCSIS multiservice, residential, and commercial IP network access over HFC networks maintained by cable television (CATV) *multiple service operators* (MSOs) needing enhanced integrated data, voice, and video in large metropolitan areas.
- Small CATV hub sites—Smaller hub sites aggregated over metropolitan fiber rings supporting Gigabit Ethernet.

Figure 2 on page 5 illustrates a typical cable headend architecture.

Figure 1: Typical CMTS Location

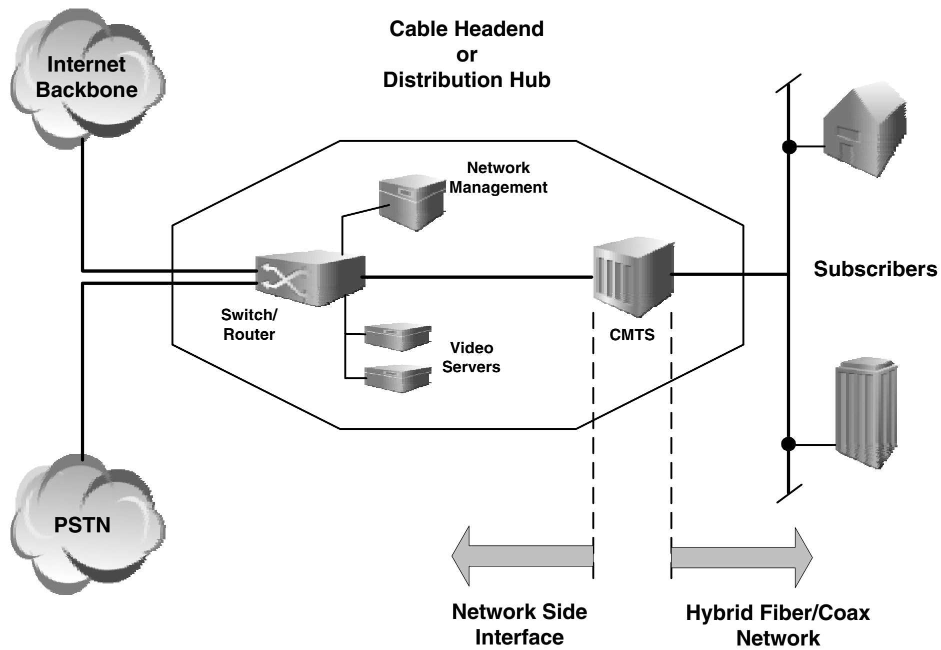
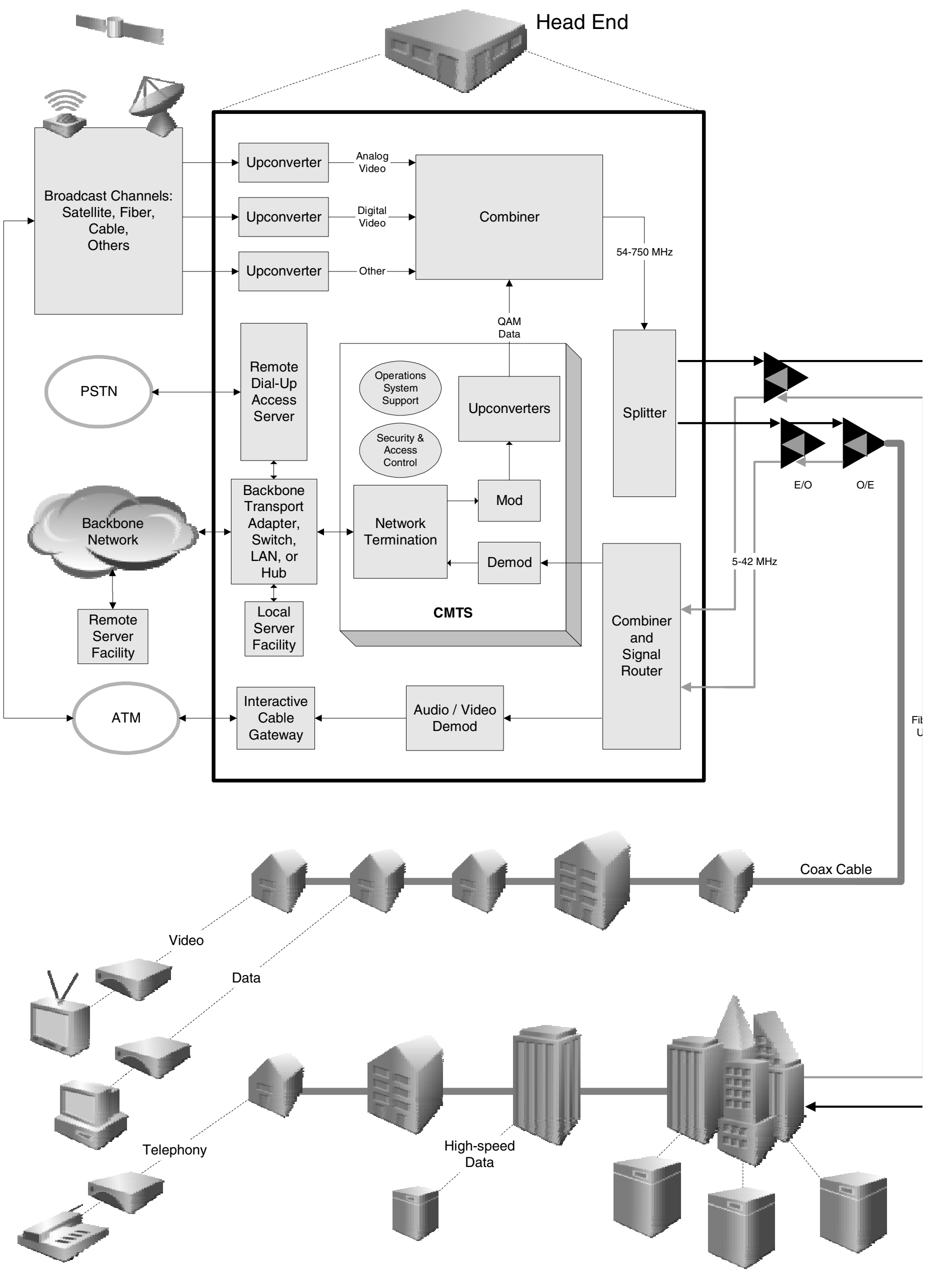


Figure 2: Headend Architecture



Field-Replaceable Units (FRUs)

Field-replaceable units (FRUs) are CMTS components that can be replaced at the customer site. Replacing FRUs requires minimal CMTS downtime. A FRU can be ordered as a separate unit for replacement into the CMTS or for stocking spare parts.

Following is an alphabetical list of G10 CMTS FRUs. See "G10 CMTS Hardware Overview" on page 10 for a description of each FRU.

- AC power supply
- AC power transition module
- Air management module
- Air management panel
- CCM Access Module
- Chassis
- Chassis Control Module
- DOCSIS Module
- DC power supply
- DC power transition module
- Front fan tray
- GBIC module
- Hard Disk Module
- HFC Connector Module
- NIC Module
- NIC Access Module
- NIC Access Module cable
- Power supply filler panel
- Rear fan tray
- Switched I/O Module (SIM)

G10 CMTS Features and Functions

The G10 CMTS provides true multiservice support, including the ability to simultaneously support DOCSIS IP services and VoIP services.

Functional Overview

The G10 CMTS is usually connected directly to a Gigabit-class core router that is part of a multiple system operator's (MSO) metropolitan core network. It receives network-side packet streams originating from the Internet, Media Gateways or video servers, then processes them into DOCSIS-compatible digital signals (MPEG) that are modulated onto an RF carrier for transmission downstream over the HFC network to the subscribers' cable modems.

Upstream signals consist of protocol data units (PDUs) in data bursts from the cable modems. The G10 CMTS uses advanced scheduling algorithms to optimize the timing of these transmissions. The packets are processed to recover the payload data, then routed, as IP packets, to the appropriate destinations through the network-side interface.

The G10 CMTS's high capacity of up to 32 downstream and 128 upstream interfaces and other innovative features are provided by the Broadband Cable Processor ASIC (application-specific integrated circuit).

Broadband Cable Processor ASIC

The Broadband Cable Processor ASIC provides all-digital processing of the return path. This, plus advanced noise cancellation and equalization algorithms, enables modulation rates beyond QPSK and allows traditionally problematic frequency ranges of the upstream spectrum to be utilized. All-digital processing also accommodates full spectrum analysis by capturing statistics of the upstream band in real time.

The Broadband Cable Processor ASIC incorporates key DOCSIS MAC (media access control) functions such as concatenation, fragmentation, encryption, and decryption. Accelerating these functions in hardware provides a high-performance, scalable CMTS solution that can process thousands of simultaneous DOCSIS service flows.

Advanced timing and digital signal processing algorithms allow more efficient use of the RF spectrum, resulting in increased channel capacity.

G10 CMTS Components

The G10 CMTS chassis employs front and rear modules that connect through a midplane. Most of the cable connections are available in the rear of the unit. Following is a list of the primary modules of the G10 CMTS:

- NIC Module—Provides Ethernet switching functionality for upstream and downstream traffic and for the Fast Ethernet interfaces. Houses two Gigabit Ethernet ports with Gigabit Interface Converters (GBICs).

- NIC Access Module—Fans out the Ethernet signals to individual 10/100Base-T lines, which route to the HFC Connector Modules or Switched I/O Modules. A version of the chassis provides internal Ethernet wiring between the NIC Modules and the DOCSIS Modules.

- DOCSIS Module—Performs all data path processing functions, including Layer 2 bridging and Layer 3 forwarding. Processes IP data into DOCSIS packets. Converts and modulates data for RF transmission. Reverses these processes for upstream data.

- HFC Connector Module—Provides cable interfaces for a DOCSIS Module. Contains the Fast Ethernet connectors for network-side data and the F-connectors for the HFC cabling.

- Switched I/O Module—Provides the same functions as an HFC Connector Module, but provides four additional upstream F-connectors for the HFC cabling.

- Chassis Control Module—Provides the management interface and runs the Routing Engine software. Controls redundant protection functions and supplies software images to all DOCSIS Modules. Runs the Simple Network Management Protocol (SNMP) agent and environmental monitoring.

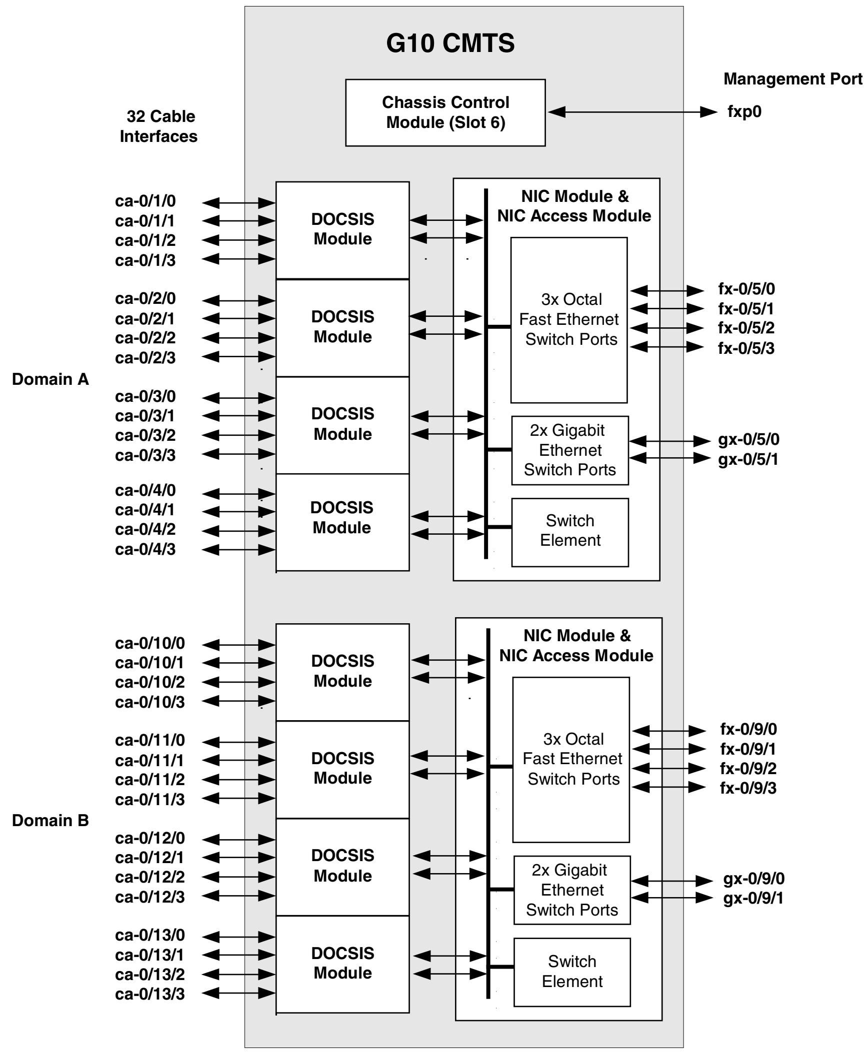
- Hard Disk Module—Contains the system nonvolatile memory implemented as a hard disk. This module is installed opposite the Chassis Control Module.

The G10 CMTS relays traffic between DOCSIS RF interfaces, on which the cable modems reside, and the network-side interfaces (Fast Ethernet and Gigabit Ethernet). Figure 3 on page 9 illustrates the relationship between the primary modules in the chassis.

Each DOCSIS Module can support up to four cable interfaces, where a cable interface (MAC domain) contains at least one downstream interface and one upstream interface. Each NIC Module supports two Gigabit Ethernet interfaces and four Fast Ethernet interfaces. The Chassis Control Module provides an out-of-band Fast Ethernet management interface.

See the *JUNOSg Software Configuration Guide: Interfaces, Cable, Policy, and Routing and Routing Protocols* for more information on interfaces.

Figure 3: G10 CMTS Components and Interfaces



G10 CMTS Management

The G10 CMTS supports the following system management applications and tools:

- Command-Line Interface (CLI)—The CLI provides the most comprehensive controls and is instrumental for installation, configuration, troubleshooting, and upgrade tasks.
- SNMP—The CMTS can interact with SNMPv2c and SNMPv3-based Network Management Systems using DOCSIS 1.0 and DOCSIS 1.1 MIBs and enterprise MIBs. Events can conditionally be reported as system log messages or SNMP traps.
- ServiceGuard Management System – This optional advanced diagnostics application with a Java GUI provides a rendition of a spectrum analyzer for acquiring data on upstream transmission cable performance. It incorporates an integrated Impairment Identification tool that allows for unattended monitoring of statistics to characterize compromised performance to a potential cause (such as impulse or burst noise, narrow band ingress, or microreflections).

G10 CMTS Hardware Overview

This section provides an overview of the modules and various hardware components of the G10 CMTS and where they reside within the chassis. This overview presents material that is specific to the installation and configuration of the G10 CMTS.

Figure 4 on page 11 illustrates a front view of a fully configured chassis. Figure 5 on page 12 illustrates a front view of a partially configured chassis in which DOCSIS Modules, a Chassis Control Module (CCM), a Network Interface Card (NIC) Module, power supplies, air management modules, and power supply filler panels have been removed. Figure 6 on page 13 illustrates a rear view of a fully configured chassis that uses the AC power transition module and HFC Connector Modules (see Figure 39 on page 122 for an illustration of the DC power transition module). Figure 7 on page 14 illustrates the rear view of the partially configured chassis in which HFC Connector Modules, a Hard Disk Module, a NIC Access Module, and air management panels have been removed. Figure 8 on page 15 provides a top view of the chassis midplane showing the slot numbering and the location of each module.

Figure 4: Front View of Fully Configured Chassis

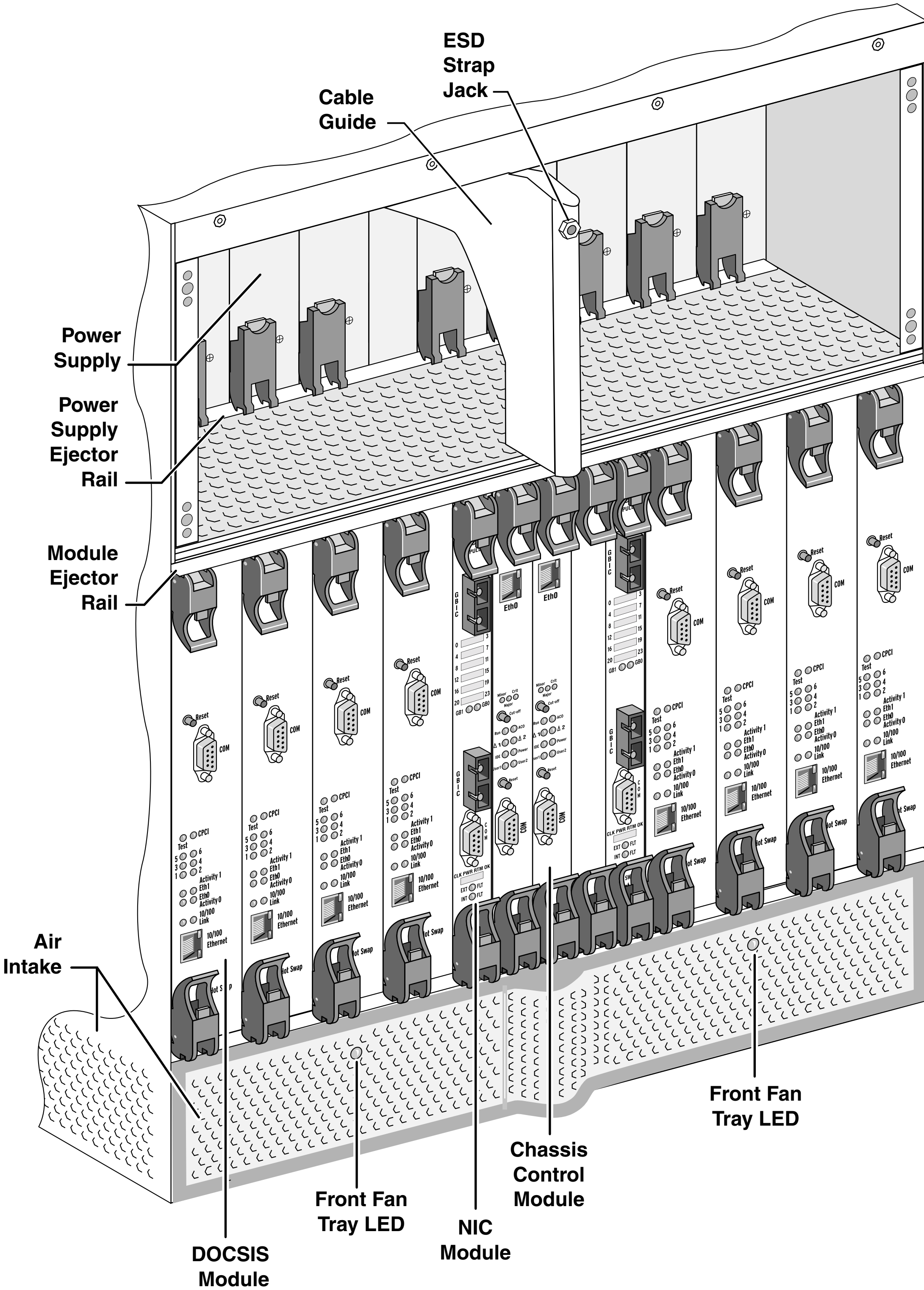


Figure 5: Front View of Partially Configured Chassis

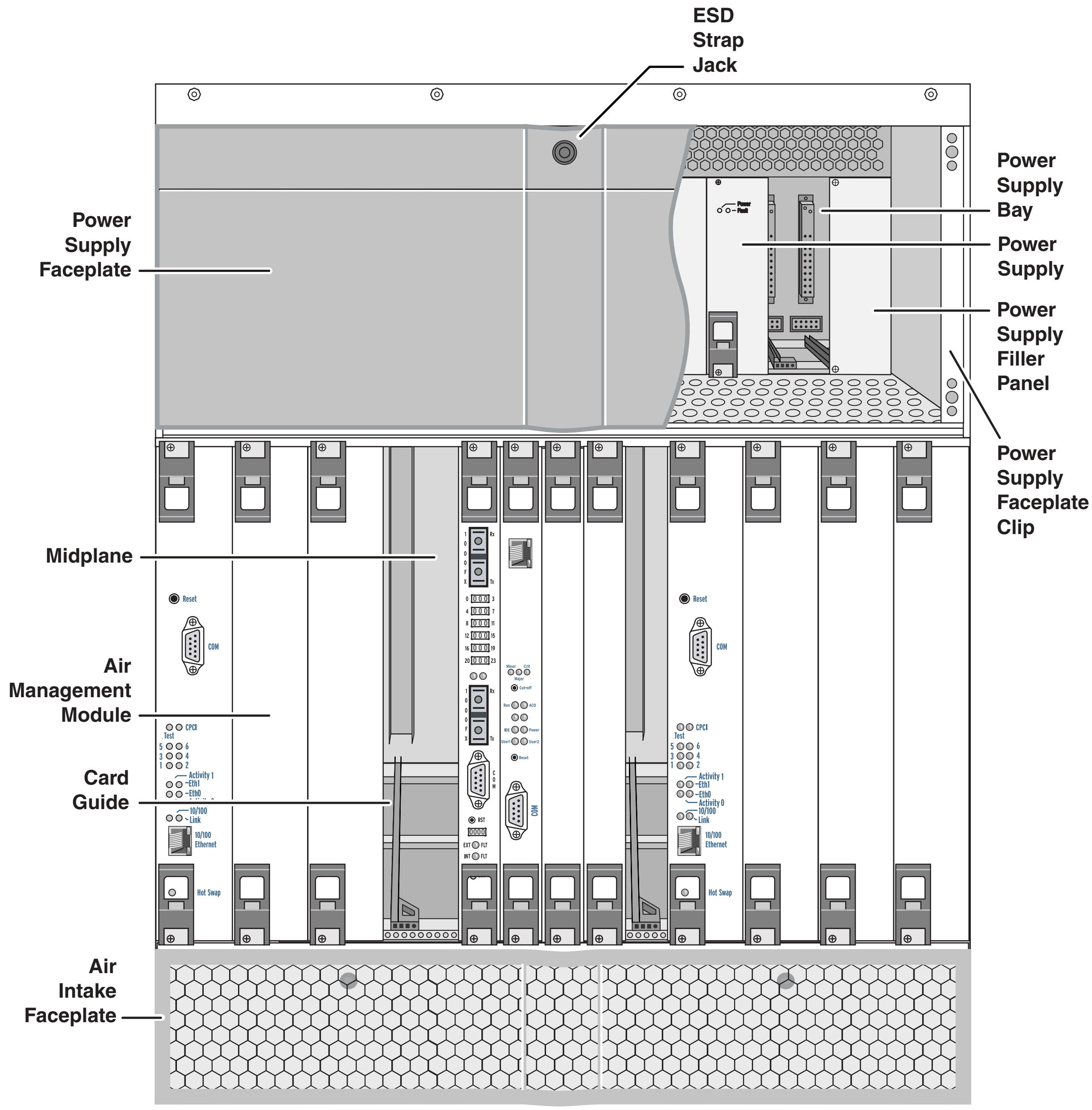


Figure 6: Rear View of Fully Configured Chassis

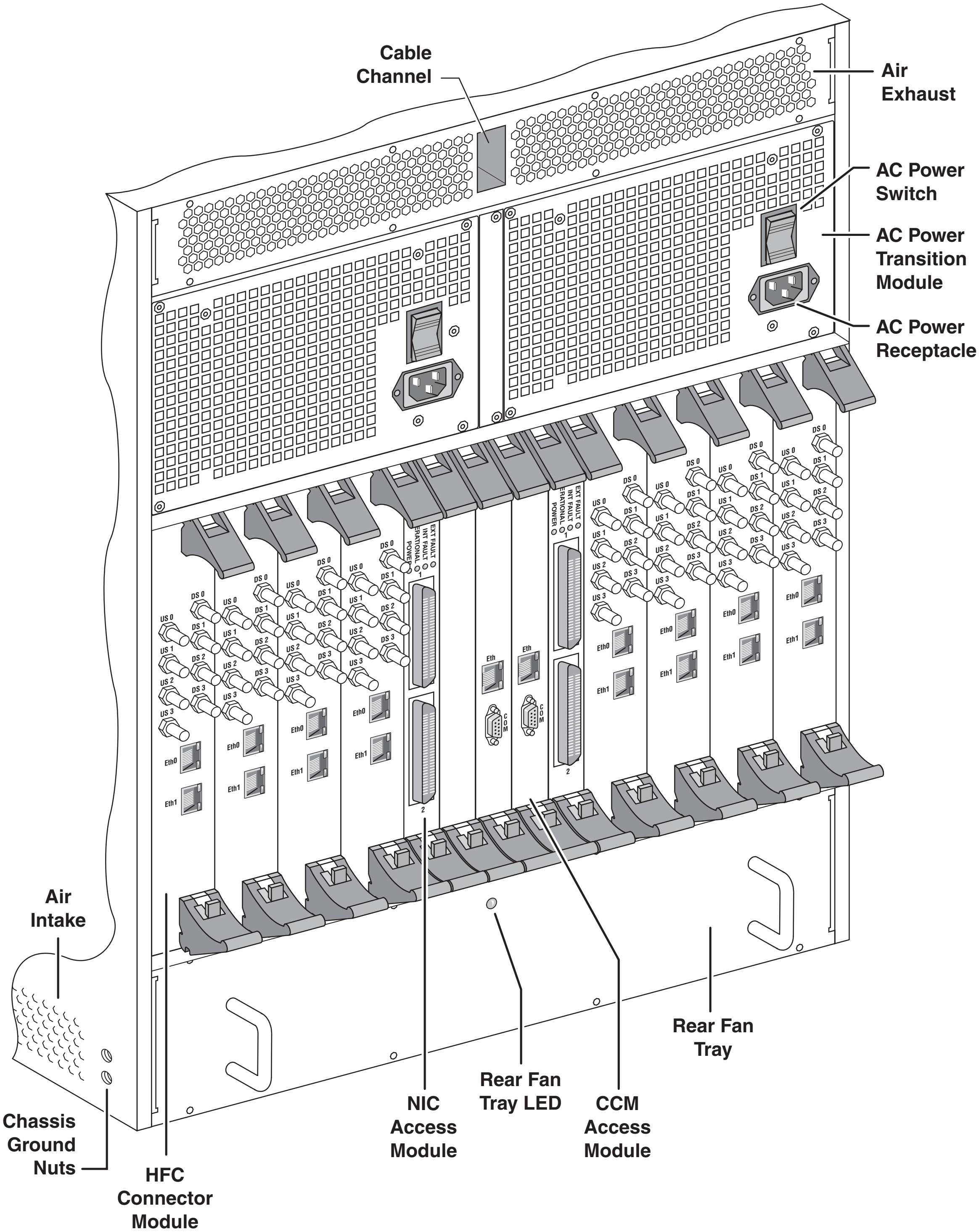


Figure 7: Rear View of Partially Configured Chassis

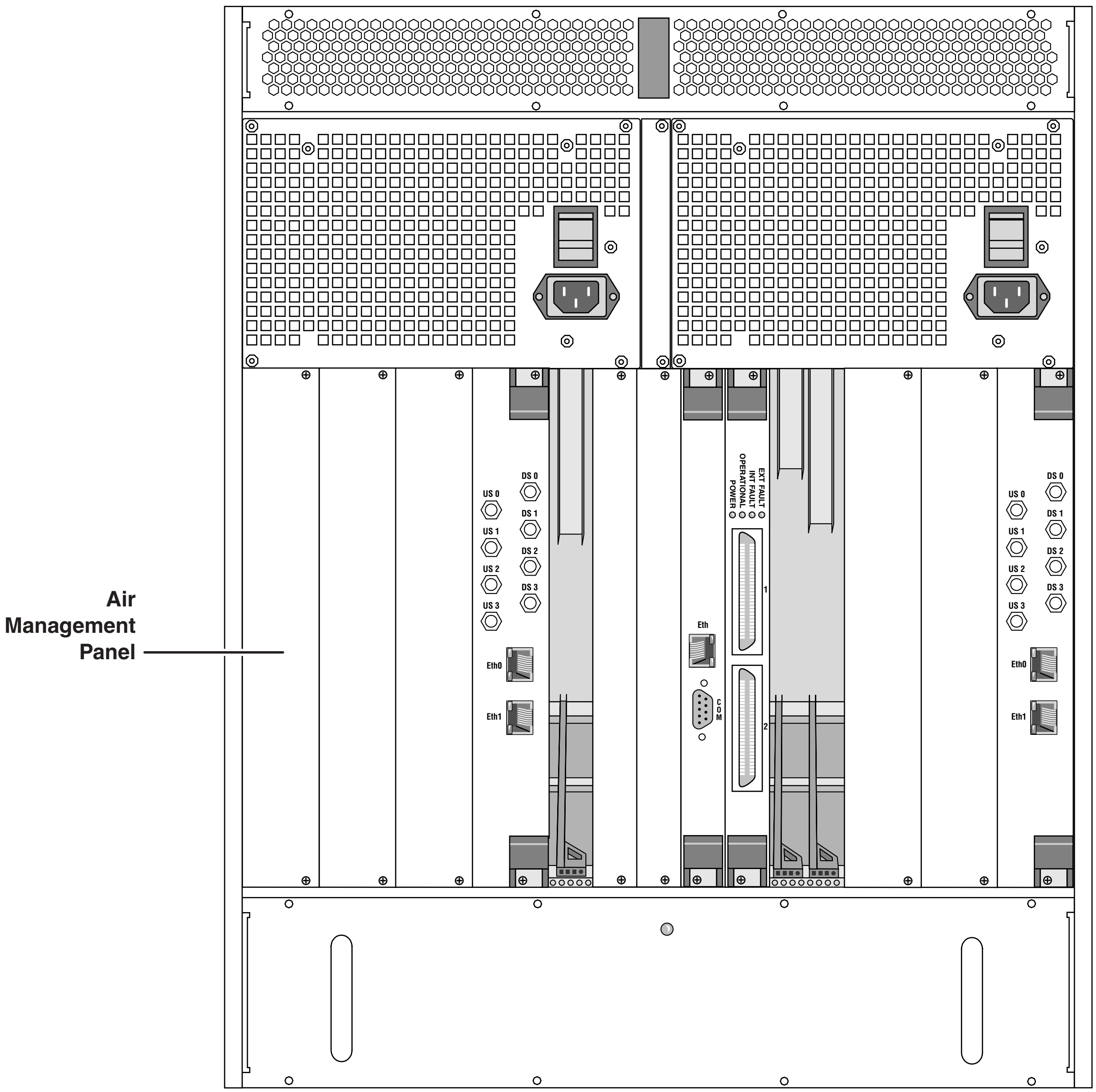
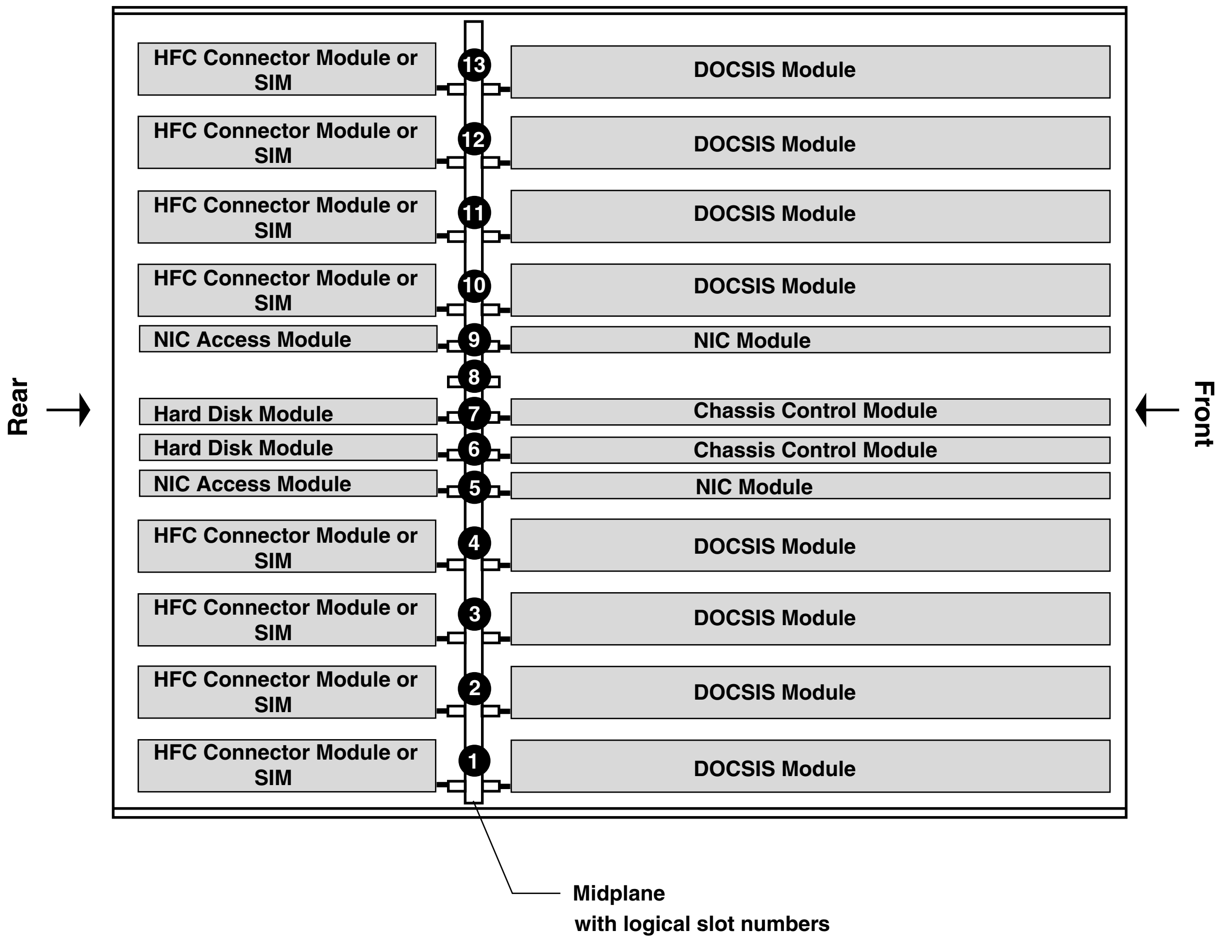


Figure 8: Chassis Top View Showing Midplane Slot Numbering



Note

Slots 1 through 6 reside in domain A. Slots 7 and 9 through 13 reside in domain B.

Following is a brief explanation of each feature shown in Figure 4 through Figure 7:

Front Features

- DOCSIS Module—Module that contains the Broadband Cable Processor ASIC and resides between the network-side interface (NSI) and the hybrid fiber/coax (HFC) interface.
- NIC Module—Module that provides the Gigabit Ethernet interface and the Fast Ethernet switching functions for the network-side interface.
- Chassis Control Module—Module that performs management and monitoring functions.
- Module ejector rail—Rail into which a module's ejector tabs fit when a module is installed in a slot.
- ESD strap connector—Location where you can insert an ESD ground strap.
- Air intake—Slotted openings along the front (removable) and sides of the chassis where air is drawn into the chassis for cooling the installed modules and power supplies.
- Air intake faceplate—Slotted removable panel that covers the two front fan trays.
- Air intake faceplate clip—Retainer clip used to mount the air intake faceplate.
- Front fan tray—Fan assembly that forces air upward through the front of the chassis.
- Front fan tray LED—LED that shows the status of the front fan tray.
- Power supply ejector rail—Rail into which the power supply ejector tabs fit when a power supply is installed in a bay.
- Midplane—Passive electrical interconnecting device for all modules in the chassis.
- Air management module—Module installed in an unused module slot to redirect the air flow through the chassis and to reduce EMI emissions.
- Card guide—Used to align a module or power supply while it is being inserted into its slot or bay.
- Power supply—Converts AC or DC power supplied through the power transition modules into the DC voltages required by the modules.
- Power supply faceplate—Panel along the top of the chassis that covers the power supplies.
- Power supply faceplate clip—Retainer clip used to mount the power supply faceplate.
- Power supply bay—Chassis bay in which a single hot-swappable power supply is inserted.
- Power supply filler panel—Panel covering an empty power supply bay.
- Cable channel—Channel through the top of the chassis that is used to route the network cables from the rear of the chassis to the front.
- Cable guide—Guide used to route the network cables between the cable channel and the lower opening in the power supply faceplate.

Rear Features

- HFC Connector Module—Module that functions as the DOCSIS Module's physical access to both the NSI and the HFC interfaces on the rear of the chassis.
- Switched I/O Module—Provides the same functions as an HFC Connector Module, but provides four additional upstream F-connectors for the HFC cabling.
- NIC Access Module—Module that provides the network connections between the NIC Modules and the HFC Connector Modules.
- Hard Disk Module—Contains the system nonvolatile memory implemented as a hard disk. This module is installed opposite the Chassis Control Module.
- Rear fan tray—Fan assembly that forces air upward through the rear of the chassis.
- Rear fan tray LED—LED that shows the status of the rear fan tray.
- Air management panel—Panel installed over an unused module slot to redirect the air flow through the chassis and to reduce EMI emissions.
- Air exhaust—Panel along the top and rear of the chassis where air is expelled from the chassis for cooling.
- AC power transition module—Rear module that distributes the externally supplied AC power to the midplane.
- AC power receptacle—AC power cord receptacle on AC power transition module.
- AC power switch—AC power On/Off switch that resides on the AC power transition module.
- DC power transition module—Rear module that distributes the externally supplied DC power to the midplane.
- DC power receptacle—DC power cord terminal block on DC power transition module.
- Chassis ground nuts—Location where the earth ground connection to the chassis is made.

Chapter 2
Hardware Component Overview

This chapter provides an overview of the G10 CMTS hardware components:

Chassis

This section discusses the following characteristics of the G10 CMTS chassis components:

The chassis is a rack-mountable, 19-inch wide, 13 U high housing that contains the modules, power supplies and fans. The chassis accepts CompactPCI standard modules that conform to dimensions specified in IEEE Standard 1101.1-1998. The use of a midplane as the interconnecting device allows modules to be installed from both the front and rear of the chassis.

See Figure 4 on page 11 and Figure 6 on page 13 for illustrations of the front and rear of a fully populated chassis.

The major components of the G10 CMTS chassis are listed below and discussed in detail in the following chapters.

- DOCSIS Module—Up to eight modules, depending on planned customer capacity.
- HFC Connector Module—Up to eight modules, one for each DOCSIS Module.

> **Note:** You cannot use an HFC Connector Module in a version 2 chassis if you are also using a NIC Module.

- SIM—Up to eight modules, one for each DOCSIS Module. The SIM can be used with a version 1 or version 2 chassis.
- Chassis Control Module—One module.
- Hard Disk Module—One module.
- NIC Module—One or two modules; one module per four DOCSIS Modules.
- NIC Access Module—One or two modules, one for each NIC Module.
- Power supply—10 units, AC or DC.
- Power transition module—Two modules, AC or DC models.
- Fan—Two front trays and one rear tray housing a total of 18 fans.

Physical Characteristics

Chassis physical and environmental specifications are provided in Table 1 on page 20 and Table 2 on page 21.

The G10 CMTS chassis is constructed of plated sheet metal. It fits into a 19-inch equipment rack that complies with EIA standard RS-310-C. You can install the chassis into a 23- inch EIA rack by attaching additional mounting brackets to the sides of the chassis. Additional rail and bracket mounting holes are provided to support installation into nonstandard racks.

Threaded nuts for chassis ground are located on the lower right side of the chassis near the rear. One ESD jack for wrist straps is located in the front upper center (see Figure 4 on page 11).

Table 1: Chassis Physical Specifications

Specification	Value
Height	578 mm (22.8 in., 13 U)
Width	480 mm (18.9 in.), excluding mounting brackets
Depth	483 mm (19.0 in.)
Weight	36 kg (80 lb) empty 64 kg (140 lb) fully populated

Table 2: Chassis Environmental Specifications

Specification	Value
Ambient temperature range (operational)	0° to +40°C (0° to +104°F)
Ambient temperature range (nonoperational)	–35° to +60°C (–31° to +140°F)
Altitude	60 m (197 ft.) below sea level to 1800 m (5,905 ft.)
Relative humidity	10% to 90% non-condensing
Vibration (operational)	5 Hz to 100 Hz and back to 5 Hz, at 0.1 g (0.1 oct/min)

Card Cage and Midplane

The card cage is the main section of the chassis that houses all the modules, which are based on circuit cards. Card cage and midplane specifications are described in Table 3. The bays for the power supplies and power transition modules sit above the card cage, and the bays for the fans sit below it (see Figure 4 on page 11).

Table 3: Card Cage and Midplane Specifications

Specification	Value
Standard module dimensions	**Module Face Plate** 262 mm (10.3 in., 6 U) height 20 mm (0.8 in.) width, single-wide 40 mm (1.6 in.) width, double-wide **Module Circuit Card** 233 mm (9.2 in.) height 340 mm (13.4 in.) depth - front modules 80 mm (3.2 in.) depth - rear modules
Midplane dimensions	487 mm (19.2 in.) height 428 mm (16.8 in.) width
Midplane card slots	13 slots spanning 21 connector columns
Module capacity (each front and rear)	8 double-wide modules (16-slot equivalent) 4 single-wide modules 1 unused single-wide slot

The midplane is the passive electrical interconnecting device for all modules in the chassis. It complies with *CompactPCI Specification 2.0 R3.0*, Oct.1, 1999. Analogous to a backplane, the midplane resides towards the middle of the chassis with connectors facing front and rear (see Figure 8 on page 15).

The G10 CMTS does not use all connector columns on the midplane. The DOCSIS Modules, HFC Connector Modules, and SIMs are an 8 horizontal pitch (HP), double-wide design covering two columns. The Chassis Control Modules and Hard Disk Modules are a 4 HP, single-wide design. Midplane slot 8 is not used. This is reflected in the slot numbering scheme.

The midplane extends the width of the chassis and the height of the chassis minus the top and bottom air chambers.

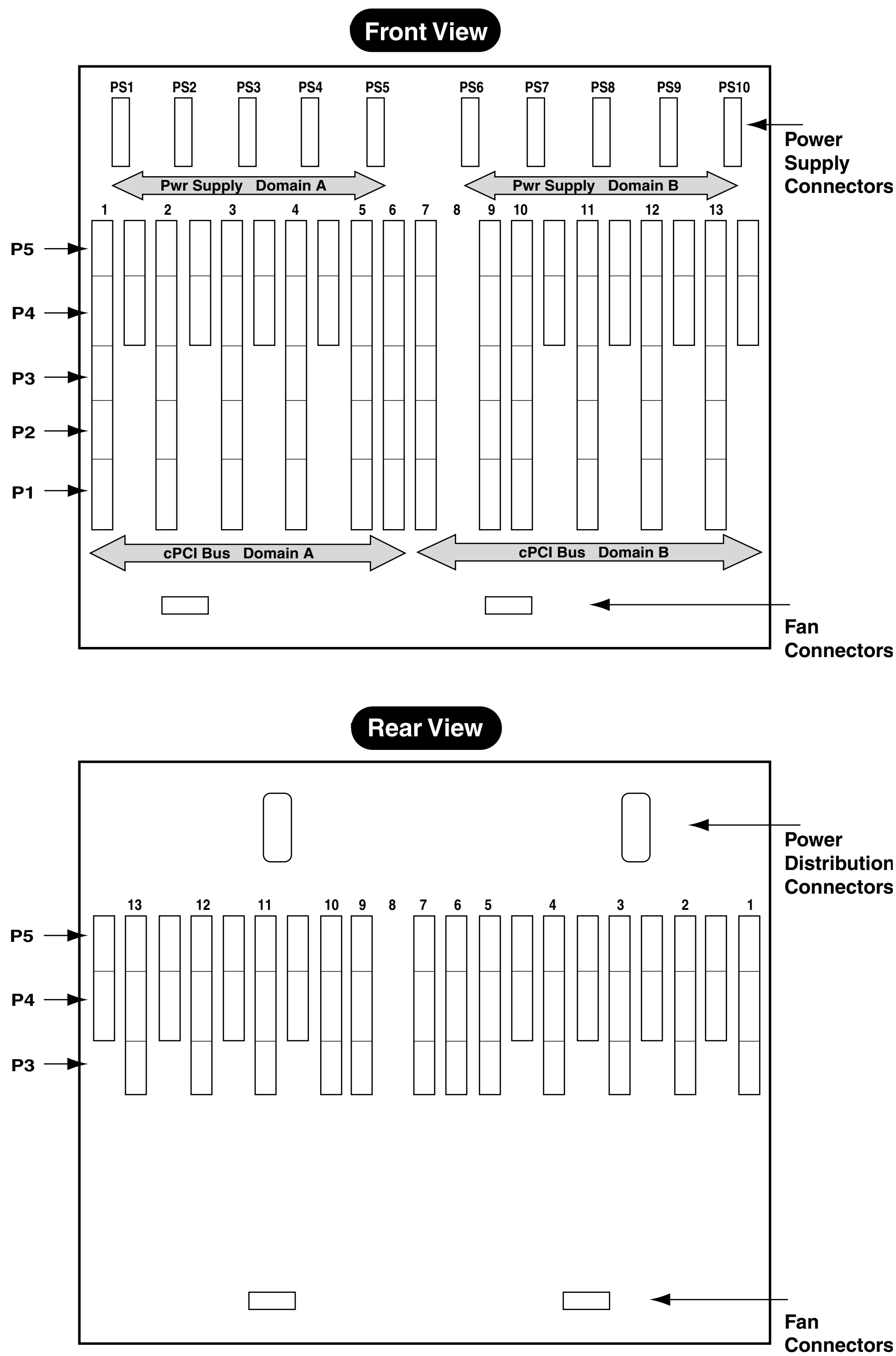
The modules in the card cage use the P1 through P5 connectors of the midplane (see Figure 9 on page 23). The power supplies use connectors PS1 through PS10. Fan trays and power transition modules also connect to the midplane.

Connectors P3 through P5 provide the pass-through interconnection between the modules in the front and rear of the chassis. Connectors P1 and P2 support the cPCI bus. The major signals carried by the connectors are described in Table 4.

Table 4: Midplane P1 – P5 Connectors

Connector	Function
P1 and P2	cPCI bus
P3	I^2C bus Ethernet to/from HFC Connector Module or SIM Synchronization and reference clocks Power and ground
P4 and P5	RF signals to HFC Connector Module or SIM IF signals from HFC Connector Module or SIM

Figure 9: Midplane—Front and Rear Views



The midplane is partitioned into domains A and B as described in Table 5. This is required by the bus length restrictions stipulated in the cPCI specification. The power supplies and power distribution panels are also separated into domains A and B.

Table 5: Midplane Configuration

Domain	Slot	Front of Midplane	Rear of Midplane
A	1	DOCSIS Module	HFC Connector Module or SIM
	2	DOCSIS Module	HFC Connector Module or SIM
	3	DOCSIS Module	HFC Connector Module or SIM
	4	DOCSIS Module	HFC Connector Module or SIM
	5	NIC Module	NIC Access Module
	6	Chassis Control Module	CCM Access Module
B	7	Chassis Control Module	CCM Access Module
	8	Blank	Blank
B	9	NIC Module	NIC Access Module
	10	DOCSIS Module	HFC Connector Module or SIM
	11	DOCSIS Module	HFC Connector Module or SIM
	12	DOCSIS Module	HFC Connector Module or SIM
	13	DOCSIS Module	HFC Connector Module or SIM

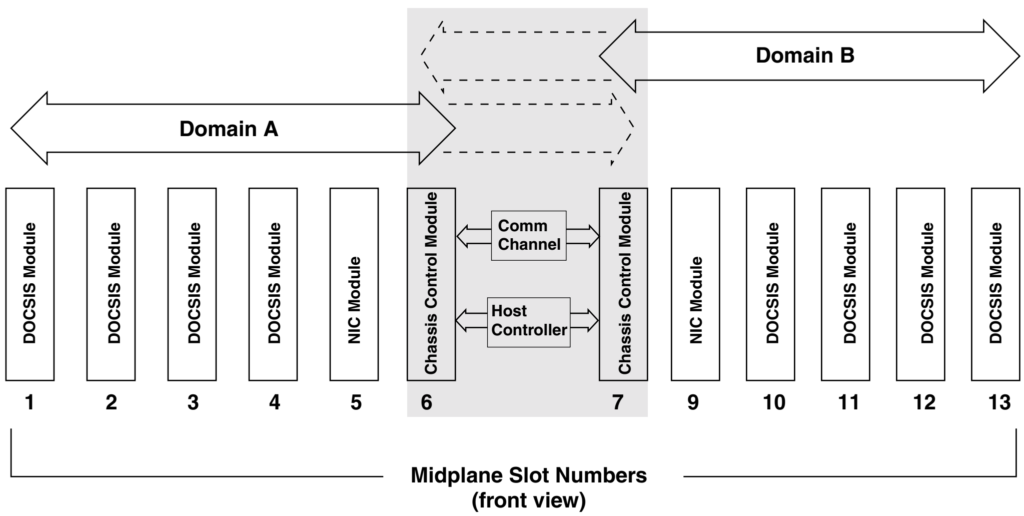
Note

Release 3.0 does not support Chassis Control Module redundancy.

The division of the domains is between slots 6 and 7. Each domain includes up to four DOCSIS Modules, a NIC Module, and a Chassis Control Module in the front, and up to four HFC Connector Modules or SIMs, a NIC Access Module, and a Hard Disk Module in the rear. The number of modules depends on your planned capacity.

The domains are bridged by the Chassis Control Module. Slots 6 and 7 are keyed to accept only a Chassis Control Module in the front and a Hard Disk Module in the rear. Peripheral interrupts, clocks, and bus arbitration signals are routed to these system slots. Continuity of the bus across the midplane is accomplished by the two cPCI buses extending beyond their system slots to connect with the system slot of the other domain, as shown in Figure 10 on page 25. The electrical connection of the Chassis Control Module to both buses is controlled by a PCI-to-PCI bridge in the module.

Figure 10: Midplane Domains



Chassis Versions

There are two versions of the chassis—version 1 and version 2. Version 2 provides all the functions provided by version 1, but contains a new midplane that provides the following features:

- Support for eight RF upstream ports from a SIM to its corresponding DOCSIS Module.
- Ethernet wiring between DOCSIS Modules and NIC Modules that eliminates the need for external NIC Access Module cables.

> **Note**
>
> When Ethernet wiring within the new midplane is used:
>
> - You must install a NIC Access Module opposite each installed NIC Module for proper Ethernet signal termination.
> - You must not connect NIC Access Module cables to the NIC Access Module.

- Ability to read the chassis version with the show chassis hardware detail command.

Power Supplies

Power supplies are available in either AC or DC input voltage models. You must specify a model when ordering a G10 CMTS. The power supplies and the chassis are mechanically keyed to ensure that the same types are used together.

If you order an AC version of the CMTS without power redundancy, the CMTS ships with five AC power supplies installed in domain A. If you order the CMTS with power redundancy, the CMTS ships with 10 AC power supplies installed. DC versions of the CMTS are always shipped with 10 DC power supplies installed.

Power redundancy provides input power redundancy as well as N + 1 power supply redundancy. You must supply power from different circuits to domain A and domain B for power redundancy protection. However, the VDC outputs of each power supply are available to all chassis modules through the power bus in the midplane.

An AC power supply front panel is shown in Figure 11 on page 27. The power supplies are in a standard 3 U housing with a 160 mm depth and a 40 mm front panel width. The power supplies install from the front of the chassis (see Figure 4 on page 11) and plug into the PS1 through PS10 connectors on the midplane (see Figure 9 on page 23). Power supplies are hot-swappable.

Since a power supply is half the depth of the other modules in the front of the card cage, the power supplies sit recessed in the chassis bay. A removable faceplate installs over the front opening.

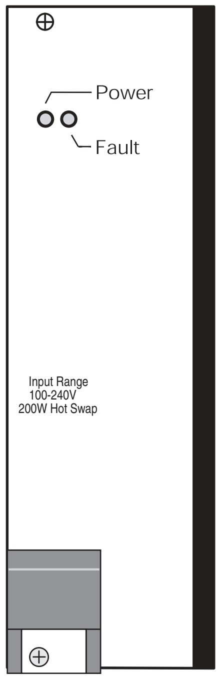
The power supply front panel contains two indicator LEDs—POWER and FAULT. Table 6 on page 26 explains the significance of these LEDs.

Table 6: Power Supply LEDs

POWER	FAULT	Meaning
Green	Not illuminated	Normal operation
Green	Red	■ Over-temperature ■ Over-current or over power limit condition
Not illuminated	Red	Voltage input failure
Not illuminated	Not illuminated	■ Power supply not installed correctly ■ No input power and no DC output from other power supplies to illuminate FAULT LED

If the power supply is operating in a degraded mode due to an increase in its temperature, a warning event is generated (if enabled). If the temperature rises to the over-temperature shutdown limit, the FAULT LED is illuminated and a critical event is generated (if enabled). Temperatures above the over-temperature shutdown limit cause the power supply to shut down. See the *JUNOSg Software Configuration Guide: Interfaces, Cable, Policy, and Routing and Routing Protocols* for more information on event configuration.

Figure 11: AC Power Supply Front Panel



A fully populated chassis requires a nominal 1500 watts from an external power source. The components of the chassis require 1000 watts (maximum) from the power supplies. The aggregate power output from all voltage levels is 200 watts per power supply. Other electrical characteristics are provided in Table 7 on page 28.

> **Note**
>
> The CMTS components do not consume their maximum power at the same time. Therefore, the CMTS maximum power requirement is less than the sum of the maximum power consumed by each component installed in the CMTS.

Table 7: Power Supply Specifications

Power Supply Type	Input Voltage	Input Current Rating	Output Voltage	Maximum Output Current
AC	90 to 240 VAC 47 to 63 Hz	2.5 A Nom (110 V, 70 percent efficiency)	+5.0 VDC	25.0 A
			+3.3 VDC	35.0 A
			+12.0 VDC	8.0 A
			–12.0 VDC	1.5 A
DC	–36 to –72 VDC	6.0 A Nom (–48 VDC)	+5.0 VDC	25.0 A
			+3.3 VDC	35.0 A
			+12.0 VDC	8.0 A
			–12.0 VDC	1.5 A

The +5.0 VDC and +3.3 VDC outputs supply a combined maximum of 175 W using load sharing.

Caution

You cannot use a 250 watt AC power supply and a 200 watt AC power supply in the same G10 CMTS chassis.

Power Transition Modules

The external power sources for the CMTS connect to the power transition modules. Two power transition modules install from the rear of the chassis and plug into the midplane opposite the power supplies in the front (see Figure 6 on page 13). The power transition modules are provided for either AC or DC power sources, depending on how the chassis is configured.

The outputs of the AC and DC power transition modules are wired differently within the midplane. An AC power transition module only supports the five power supplies within its domain. However, because the outputs of each DC power transition module are wired together along the midplane, each DC power transition module supplies power to all 10 DC power supplies in the chassis.

Full power redundancy consists of redundant power supplies, power transition modules, and power sources. All G10 CMTS systems are shipped with two power transition modules installed, one per domain, to implement power transition module redundancy. This also facilitates power source redundancy. You must supply power from different circuits to each power transition module to implement power source redundancy.

Each AC module has a double-pole rocker switch that serves as a power switch for the chassis. The switch is recessed to prevent accidental activation.

The AC panel has a standard IEC 15-A receptacle with a three-prong male plug for connecting to a power source. The DC panel has a 40-A terminal block with barrier guards for single lug connections to the source and return.

Cooling and Fans

The G10 CMTS has three fan trays. The trays install into the air intake chambers in the bottom of the chassis. Two trays install from the front and one tray installs from the rear. The front trays contain six large fans each and the rear tray contains six smaller fans. The total maximum power consumption of the three fan trays is 165 watts.

Each tray has one LED. If a single fan fails, the LED illuminates red and a warning event is generated (if enabled). If multiple fans fail, a critical event is generated (if enabled). See the *JUNOSg Software Configuration Guide: Interfaces, Cable, Policy, and Routing and Routing Protocols* for more information on event configuration.

The Chassis Control Module monitors the internal temperature of the chassis in multiple locations. If the temperature is maintained between a lower and an upper threshold, the fans continue to rotate at a nominal speed. If the temperature exceeds the upper threshold, the speed of the fans and the value of the upper threshold are incrementally increased. Likewise, if the temperature drops below the lower threshold, the speed of the fans and the value of the lower threshold are incrementally decreased. This process continues until the temperature and fan speed settle between the latest thresholds.

These temperature thresholds cannot be changed by a user. However, you can set user-defined temperature thresholds by including the temperature-threshold statement at the [edit chassis] hierarchy level (see the *JUNOSg Software Configuration Guide: Getting Started and System Management* for more information).

The chassis directs the air flow upward through the card cage, then past the power supplies and power transition modules. There is a 97-mm high air intake chamber with front and side openings at the bottom of the chassis. Air exits through a 71-mm high chamber at the top of the chassis through a rear opening and through the power transition modules in the rear.

The presence of the various modules is part of the air flow design. In a chassis that is not fully populated, you must install air management modules, air management panels, and power supply filler panels in all unused module slots to maintain proper air flow. You must also install the power supply faceplate to ensure proper air flow.

The G10 CMTS must be installed in an open rack to ensure adequate air flow.

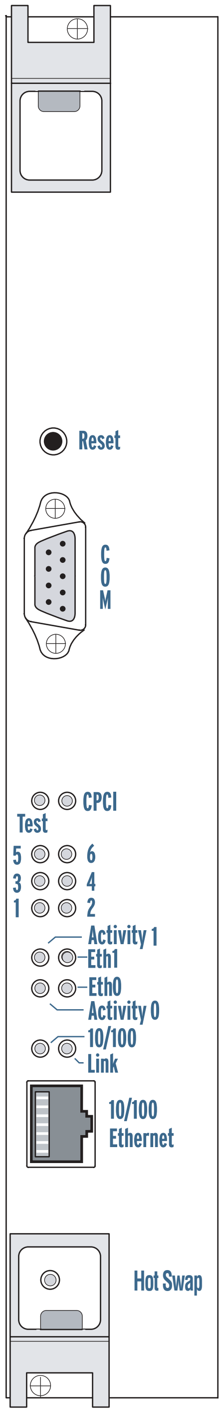
DOCSIS Module

The DOCSIS Module contains the circuits, devices (including the Broadband Cable Processor ASIC), and code that provide the core functionality and features of the G10 CMTS.

The DOCSIS Module connects with the HFC Connector Modules or SIMs in the rear of the chassis through the midplane. This keeps the cabling in back of the chassis. See “HFC Connector Module” on page 50 and “Switched I/O Module” on page 53 for more discussion.

Figure 12 on page 30 shows the DOCSIS Module front panel.

Figure 12: DOCSIS Module Front Panel



Functional Characteristics

The DOCSIS Module is fully compliant with *CompactPCI Specification 2.0 R3.0*, Oct.1, 1999. The module contains a 6 U (267 mm) x 340 mm card with an 8 HP (40 mm), double-wide front panel. Physical dimension are provided in Table 8 on page 36. The module installs from the front of the chassis and is hot-swappable.

Each DOCSIS Module has a companion HFC Connector Module or SIM on the back side of the midplane (see Figure 8 on page 15). All network-side traffic and HFC-side traffic transmitted and received by the DOCSIS Module passes through the midplane to and from the HFC Connector Module or SIM. Thus, no external connections to the DOCSIS Module are required from the front of the chassis for normal operation.

Downstream data flow comes to the DOCSIS Module from the HFC Connector Module or SIM in the form of Internet data in IP packets. The module performs various processes described in "Data Packet Processing" on page 32. The data is encapsulated first into DOCSIS frames, then into an MPEG transport stream. The transport stream is modulated onto an RF signal for downstream distribution to the cable modems.

The upstream data flow is contained in PDUs (protocol data units) of varying length transmitted as TDMA bursts on specifically allocated frequencies. This process is controlled by advanced timing algorithms.

The DOCSIS Module also has other innovations to achieve high levels of density and performance. It combines the high-density Broadband Cable Processor ASIC with four 500 MHz MPC7410 processors for high-performance network edge processing in an asymmetric multiprocessing architecture. The 60x system bus connecting the MPC7410 processors has a data rate of 8 Gbps. This module contains 384 MB of RAM, 128 KB of NVRAM, and 1.5 MB of flash memory.

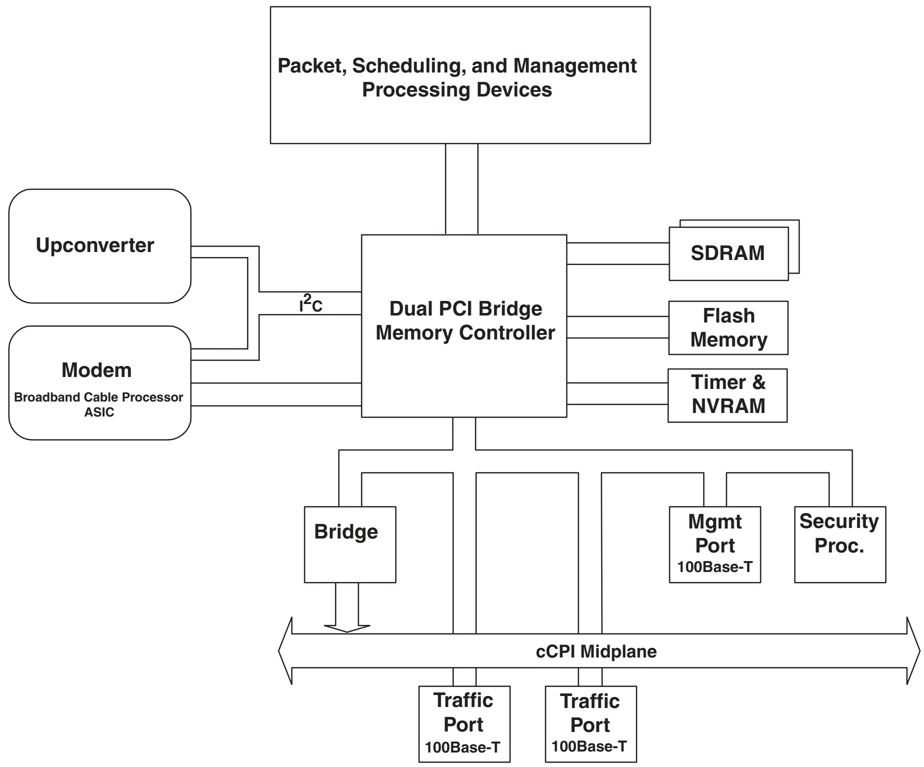
It runs DOCSIS MAC protocols, the scheduler, and all data path processing such as packet filtering, rate-limiting, traffic shaping, and 802.1D bridging. The Broadband Cable Processor ASIC provides hardware assist for the following functions: MAC protocol, scheduling, concatenation, fragmentation, encryption and decryption, spectrum analysis, noise cancellation, pre-equalization, and per-SID (Service Identifier) statistics.

The proprietary Broadband Cable Processor ASIC supports up to four downstream and eight or 16 upstream interfaces (depending on the DOCSIS Module model). It enables the implementation of QPSK and 16QAM modulation on upstream channels with very low packet loss in the presence of noise. This allows tighter scheduling of packets, thereby efficiently utilizing more of the RF spectrum. Downstream modulation uses 64QAM or 256QAM.

With up to eight DOCSIS Modules per chassis, the maximum interface capacity is 32 downstream interfaces and 128 upstream interfaces.

Figure 13 on page 32 shows a block diagram of the DOCSIS Module and Figure 14 on page 33 shows the packet processing flow.

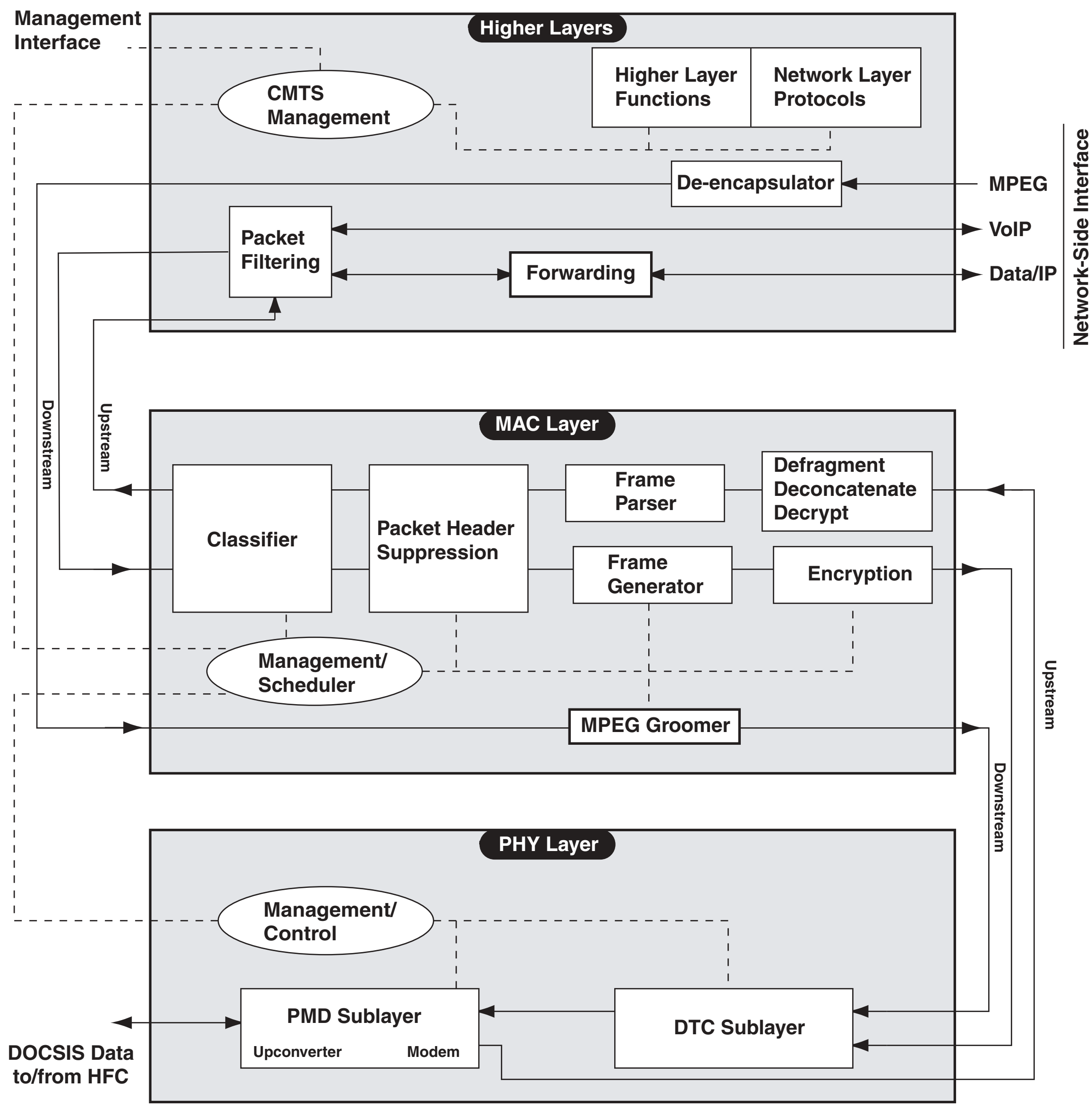
Figure 13: DOCSIS Module Block Diagram



Data Packet Processing

This section describes the major processing functions performed at the PHY, MAC, and higher protocol layers for DOCSIS 1.1 and EuroDOCSIS 1.1 compliance. Figure 14 on page 33 illustrates these functions. See the DOCSIS specifications for more details.

Figure 14: Packet Processing Layers



Higher Layer Functions

The DOCSIS Module provides the following higher layer functions:

- Packet filtering and forwarding—Filters Layer 2, Layer 3, Layer 4, and above based on DOCSIS 1.1 filter functionality.
- CMTS management—SNMP, MIBs, and CLI (command-line interface).
- Network-side interface (NSI)—IP data and VoIP interfaces.

MAC Layer Functions

The DOCSIS Module provides the following MAC layer functions:

- Classifier—Classifies upstream data frames into higher layer packet flows; classifies downstream frames into corresponding service flows using service flow IDs (SFIDs).
- Frame generator—Encapsulates downstream packets into DOCSIS frames.
- Encryption—Encrypts downstream data frames in accordance with the DOCSIS Baseline Privacy and Baseline Privacy Plus standards.
- Decryption—Decrypts upstream data.
- Fragmentation/concatenation—Reassembles upstream fragmented MAC frames and deconcatenates concatenated MAC frames.
- Frame parser—Parses DOCSIS MAC header, identifies packet as data or management, and routes accordingly. Verifies header checksum (HCS) and cyclical redundancy checking (CRC).
- MAC management—Provides cable modem, service flow, and RF management functions. Performs resource allocation scheduling of requests, service flows, QoS, and other items. Handles cable modem and service flow admission control.

Physical Layer Functions

The DOCSIS Module provides the following physical layer functions:

- Downstream transmission convergence (DTC) sublayer:
  - Manages the use of internal or external clock in MPEG transport stream; inserts timestamp.
  - Examines packets for DOCSIS PID (packet identifier) and MPEG null PID and multiplexes queued data packets into available MPEG packets.
  - Re-stamps DOCSIS PID with MPEG null PID if no data is queued for transmission.
- Physical media dependent (PMD) sublayer:
  - Frames downstream MPEG packets by substituting synchronization byte with parity checksum.
  - Implements FEC (forward error correction) and interleaving downstream; descrambles data and decodes FEC upstream.
  - Modulates to IF baseband and upconverts to RF for downstream traffic; demodulates upstream traffic.
  - Monitors upstream performance characteristics such as timing, frequency offset, BER (bit error rate), and RF spectrum.

Modem Management

The DOCSIS Module exercises functional management over MAC layer and cable modem processes.

MAC Layer Scheduling

Management at the MAC layer includes the following scheduling functions:

- Queueing upstream requests.
- Transmission opportunity allocation based on MAC messages from cable modems.
- QoS scheduling requirements, including congestion control, which have priority over normal service flows.
- Prioritizing service flows for least delay.
- Maintenance opportunity allocation, including initial maintenance alignment.

Cable Modem Management

The DOCSIS Module performs the following cable modem management functions:

- Registration of cable modems by service identifier (SID) assignments, and recording time and address failures.
- Ranging by adjusting timing offset, transmit power, carrier frequency, and transmit equalizer taps.

Enhanced Routing and Bridging Features

The DOCSIS Module provides the following enhanced routing and bridging features that provide additional value to MSOs:

- Simultaneous IP routing (Layer 3) and IEEE 802.1 bridging (Layer 2).
- ARP proxy.
- Address authentication for ARP and IP packets.
- 802.1Q and stacked 802.1Q VLANs.
- Security and service class assignment to multicast service flows.
- IGMP packet snooping.

See the *JUNOSg Software Configuration Guide: Getting Started and System Management* and the *JUNOSg Software Configuration Guide: Interfaces, Cable, Policy, and Routing and Routing Protocols* for more information on these and other DOCSIS Module features.

Physical and Electrical Characteristics

This section describes the physical and electrical characteristics of the DOCSIS Module. See Table 8 through Table 10.

The DOCSIS Module installs into the chassis from the front and spans two midplane connector columns. The module includes the RF upconverter and modem subassemblies. The module connects to the midplane through connectors J1 through J5. See "Card Cage and Midplane" on page 21 for related information.

The front panel connectors are not used.

Each DOCSIS Module with its subassemblies consumes 120 watts maximum power.

Table 8: DOCSIS Module Physical Dimensions

Dimension	Value
Height	233 mm (9.2 in.) card 262 mm (10.3 in., 6 U) front panel
Width	40 mm (1.6 in.) (front panel width)
Depth	340 mm (13.4 in.) (excluding front panel and cPCI connectors)

Table 9: DOCSIS Module Operational Characteristics

Characteristic	Downstream	Upstream
Frequency Range	91 through 857 MHz	5 – 42 MHz
Power level	+50 through +61 dBmV (adjustable)	+8 to +55 dBmV (16QAM) +8 to +58 dBmV (QPSK)
Modulation	64QAM and 256QAM	QPSK, 16QAM
Transmission protocol	DOCSIS MPEG	Frequency-agile TDMA
Symbol rate	5.057 Mbaud (64QAM) 5.361 Mbaud (256QAM)	160, 320, 640, 1280, and 2560 (user configurable)
Data rate (Max.)	40 Mbps/interface	10 Mbps/interface
Interfaces	4	8 or 16 (depending on the DOCSIS Module model)

Table 10: DOCSIS Module LEDs

LED Label	Color	Function
CPCI	Green	On—cPCI bus is active. Off—No activity on bus.
Test	Green / Red	Green Blinking—Self-test running. Green On—Self-test passed. Red On—Self-test failed. Off—Self-test not running.

LED Label	Color	Function
1	Red / Yellow / Green	Red—Operating system image loaded for CPU0. Yellow—Control transferred to CPU0 operating system. Green—Operating system initialization completed successfully on CPU0.
2	Red / Yellow / Green	Red—Operating system image loaded for CPU3. Yellow—Control transferred to CPU3 operating system. Green—Operating system initialization completed successfully on CPU3.
3	Red / Yellow / Green	Red—Waiting to connect to boot server on Chassis Control Module. Yellow—Established connection with boot server on Chassis Control Module. Green—Obtained boot instructions from Chassis Control Module.
4	Red / Yellow / Green	Red—Operating system image loaded for CPU2. Yellow—Control transferred to CPU2 operating system. Green—Operating system initialization completed successfully on CPU2.
5	Red / Yellow / Green	Red—Waiting to establishing link-layer connectivity with Chassis Control Module. Yellow—Waiting to establishing IP connectivity with Chassis Control Module. Green—IP connectivity with Chassis Control Module established.
6	Red / Yellow / Green	Red—Operating system image loaded for CPU1. Yellow—Control transferred to CPU1 operating system. Green—Operating system initialization completed successfully on CPU1.
Eth0	Green	On—Link is present on traffic port Eth0. Off—No link present.
Eth1	Green	On—Link is present on traffic port Eth1. Off—No link present.
Activity 0	Green	On—Activity is present on traffic port Eth0. Off—No activity present.
Activity 1	Green	On—Activity is present on traffic port Eth1. Off—No activity present.
Link	Green	On—Link present. Off—No link.
10/100	Amber	On—100Base-T mode. Off—10Base-T mode.
Hot Swap	Blue	ON—Module is ready to be removed. Illuminates after the ejector release is pressed. During hot insertion, LED is ON until ejectors are locked. OFF during power up.

Chassis Control Module

The Chassis Control Module performs management and monitoring functions for the G10 CMTS, and it provides a single access point for operational and maintenance functions. In addition, the Chassis Control Module runs the Routing Engine.

The Chassis Control Module connects with the Hard Disk Module in the rear of the chassis through the midplane. This provides an Ethernet port at the rear of the chassis as well as the front. See “Hard Disk Module” on page 55 for more discussion.

Figure 15 on page 39 shows the Chassis Control Module front panel.

Functional Characteristics

The Chassis Control Module contains a 6 U (267 mm) x 340 mm card with a 4 HP (20 mm), single-wide front panel. The module installs from the front of the chassis and is hot-swappable. A Chassis Control Module must be installed in slot 6 or slot 7. These slots and the Chassis Control Module are keyed so no other module can be installed in slot 6, and the Chassis Control Module cannot be installed in any other slots.

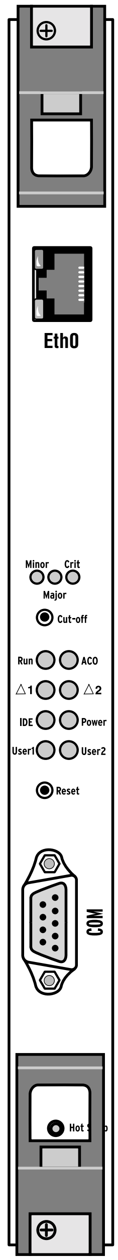
The Chassis Control Module is the single access point to the G10 CMTS for a command-line interface or SNMP management application from a remote location. The Fast Ethernet port Eth0 is used for this purpose. For connecting to the Chassis Control Module locally, use the Eth0 port or the RS-232 COM port on the front panel. All DOCSIS Modules can be managed through the Chassis Control Module.

The primary functions of the Chassis Control Module are as follows:

- Store and report configuration and alarm status on DOCSIS Modules and itself.
- Supply software images to all DOCSIS Modules.
- Serve as the SNMP agent for the CMTS.
- Provide the command-line interface.
- Run the CMTS's Routing Engine.
- Support the subscriber account management (SAM) interface.
- Monitor the state of power supply and fan modules (see "Cooling and Fans" on page 29).

The Chassis Control Module contains a 500 MHz, Pentium III processor, 512 MB of RAM, and 256 MB CompactFlash, all delivering 1,300 MIPS of performance.

Figure 15: Chassis Control Module Front Panel



Configuration, State, and Alarm Data

The Chassis Control Module stores configuration files for all DOCSIS Modules and itself. When a module boots, the Chassis Control Module sends the appropriate configuration file to that module. Configuration files are ASCII text in a format readable by the command-line interface. Users can edit these files on the CMTS or on an external host with any standard text editor (see the *JUNOSg Software Configuration Guide: Getting Started and System Management* for more information on configuration). The Chassis Control Module also provides configuration data to management applications.

The Chassis Control Module polls each DOCSIS Module for state information, then stores that data. This includes ranging and registration data on the cable modems and a backup of the DOCSIS Modules' memory and tables. Polling occurs at regular intervals to keep the data current.

The Chassis Control Module collects and stores events from itself and the DOCSIS Modules within the local event log. It uses this information to control the LEDs and provides this data to management applications.

The Chassis Control Module monitors the power supplies for the failure and degraded performance signals that they generate.

The Chassis Control Module monitors the fans for failures. If a fan in any of the multifan trays fails, the module sends a signal to increase the speed of the remaining fans and conditionally generates an event.

Physical and Electrical Characteristics

This section describes the physical dimensions, electrical characteristics, and components of the front panel of the Chassis Control Module. See Table 11 through Table 14 on page 41.

The Chassis Control Module installs into the chassis from the front. Midplane slots 6 and 7 are designated for this module. One module is required to manage the chassis.

Each Chassis Control Module consumes 29 watts maximum power.

Table 11: Chassis Control Module Physical Dimensions

Specification	Value
Height	233 mm (9.2 in.) module 262 mm (10.3 in., 6 U) front panel
Width	20 mm (0.8 in.) (front panel width)
Depth	340 mm (13.4 in.) (excluding front panel and cPCI connectors)

Table 12: Chassis Control Module Connectors

Connector Label	Function
COM	RS-232 DB-9 connector for serial interface.
Eth0	Fast Ethernet RJ-45 connector for CMTS management.

Table 13: Chassis Control Module Switches

Switch Label	Function
Cut-off	Disables audible alarm signals. Causes ACO LED to illuminate.
Reset	Depress for < 2 sec—Soft reset. Module is reinitialized. Depress for > 2 sec—Hard reset. All module components, except Host Controller, are reset.

Table 14: Chassis Control Module LEDs

LED Label	Color	Function
Minor	Green	On—Event of priority Warning, Notice, Information, or Critical has occurred.
Major	Amber	On—Event of priority Error has occurred.
Crit	Red	On—Event of priority Emergency, Alert, or Critical has occurred.
Run	Green / Red	Green—Module is active. Red—Module has been deactivated.
ACO	Green	On—Alarm Cutoff is activated.
Δ1 Δ2	Green	On—Active module. Off—Stand-by module (not used).
IDE	Green	Not used.
Power	Green / Red	Green—Power on. Red—Fault present.
USR1	Bi-color	Not used.
USR2	Bi-color	Not used.
Hot Swap	Blue	ON—Module is ready to be removed. Illuminates after the ejector release is pressed. During hot insertion, LED is ON until ejectors are locked. OFF during power up.

NIC Module

The NIC Module provides a GBIC-based network-side interface for the G10 CMTS, as well as Ethernet switching functions. Four versions of this module are available:

- Single mode, long range—Optical interface for long haul network connections, up to 80 kilometers.
- Single mode, midrange—Optical interface for midrange network connections, up to 10 kilometers.
- Multimode—Optical interface for short haul network connections, up to 550 meters. This is the default configuration.
- 1000BT mode—Electrical interface for very short haul network connections, less than 100 meters.

The version of the NIC Module installed is determined by the GBIC (Gigabit Interface Converter) modules you have installed. The GBIC module houses the network connectors and associated interface circuitry. These modules are field-replaceable units.

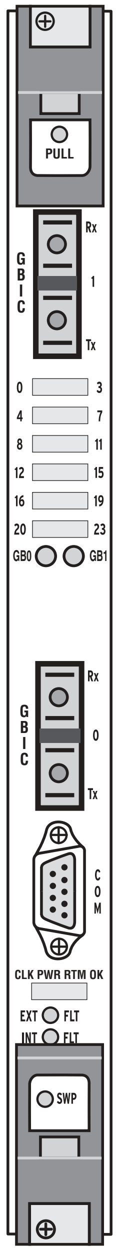
The NIC Module also provides Fast Ethernet switch ports that can be used in conjunction with the GBIC connectors. They are accessible on the NIC Access Module cable (see “NIC Access Module” on page 48).

The NIC Module connects with the NIC Access Module in the rear of the chassis through the midplane. This keeps the cabling in back of the chassis.

> **Note**
> The NIC Module does not support the spanning tree protocol (STP). BPDU packets are not forwarded by the NIC Module.

Figure 16 on page 43 shows the NIC Module front panel.

Figure 16: NIC Module Front Panel



Functional Characteristics

The NIC Module contains a 6U (267 mm) x 340 mm card with a 4 HP (20 mm), single-wide front panel. The module installs from the front of the chassis and is hot swappable.

The NIC Module provides the network-side interface of the G10 CMTS. It provides two Gigabit Ethernet and 24 Fast Ethernet switch ports (eight ports are used for DOCSIS Module connectivity, four ports are for general purposes, and 12 ports are reserved for future use). The NIC Module aggregates all upstream traffic from the DOCSIS Modules and routes it to one or more of the switch ports. The NIC Module distributes all downstream traffic from the switch ports to the DOCSIS Modules. See “HFC Connector Module” on page 50 and “Switched I/O Module” on page 53 for more information on traffic routing.

The NIC Module is powered by a 266 MHz MPC8240 processor and contains a 64 MB SDRAM buffer, 32 MB of system memory, and a 32.5 MB flash memory, all delivering 6.6 million pps switching capacity.

Physical and Electrical Characteristics

This section describes the physical dimensions, electrical characteristics and components of the front panel. See Table 15 on page 44 through Table 21 on page 47

The NIC Modules install from the front and occupy midplane slots 5 and 9. To maximum the number of MAC addresses supported, we recommend you use one NIC Module for each of the two domains (A and B) of the chassis.

Each NIC Module consumes 36 watts maximum power.

Table 15: NIC Module Physical Dimensions

Specification	Value
Height	233 mm (9.2 in.) module 262 mm (10.3 in., 6 U) front panel
Width	20 mm (0.8 in.) (front panel width)
Depth	340 mm (13.4 in.) (excluding front panel and cPCI connectors)

Table 16: NIC Module Connectors

Connector Label	Function
0 and 1	Duplex Gigabit Ethernet interface converters with SC optical connectors, or HSSDC serial connector for 1000BT mode.
COM	RS-232 DB-9 connector for serial interface.

Table 17: Single-Mode, Long-Range GBIC Specifications

Parameter	Value
Transmitter type	Longwave laser, 1550 nm
Range	80 Km
Data rate (nominal)	1.0625 to 1.250 Gbps
Average launch power	-4 dBm min. -1 dBm max.
Transmitter extinction ratio	9 dB min.
Data format	8B / 10B
Average receive power	-25.5 dBm min. -1 dBm max.
Connector	Duplex SC
Regulatory	Class 1 devices per FDA/CDRH and IEC-825-1 laser safety regulations

Table 18: Single-Mode, Midrange GBIC Specifications

Parameter	Value
Transmitter type	Longwave laser, 1310 nm
Range	10 Km
Data rate (nominal)	1.0625 to 1.250 Gbps
Average launch power	-8 dBm min. -3 dBm max.
Transmitter extinction ratio	9 dB min.
Data format	8B / 10B
Average receive power	-19 dBm min. -26.5 dBm typical -3 dBm max.
Connector	Duplex SC
Regulatory	Class 1 devices per FDA/CDRH and IEC-825-1 laser safety regulations

Table 19: Multimode GBIC Specifications

Parameter	Value
Transmitter type	Shortwave laser, 850 nm
Range	550 m
Data rate (nominal)	1.0625 to 1.250 Gbps
Average launch power (62.5 μm MMF)	-9.5 dBm min. -5 dBm max.
Transmitter extinction ratio	9 dB min.
Data format	8B / 10B
Average receive sensitivity	-22 dBm typical -20.5 dBm max.
Connector	Duplex SC
Total Tx jitter contribution	45 psec typical
Total Tx + Rx jitter contribution	50 psec typical
Output rise/fall time	120 psec typical
Regulatory	Class 1 devices per FDA/CDRH and IEC-825-1 laser safety regulations

Table 20: 1000BT GBIC Specifications

Parameter	Value
Data rate	1000BaseT
Connector	RJ-45
Transmitter type	CAT 5 twisted pair

Table 21: NIC Module LEDs

LED	Color	Function
Pull	Red	On—Module software is in a safe state; module can be removed. LED is on during power up and off during normal operation.
0 through 23	Green	On—Successful link of the corresponding Ethernet interface. FLASHING—Activity on corresponding channel. LEDs are off during power up.
GB0 GB1	Green	On—Successful link of corresponding Gigabit Ethernet interface. LED is off during power up.
CLK	Green	Not used. LED is on during power up and off during normal operation.
PWR	Green	On—Power is applied to the module. LED is on during power up.
RTM	Green	On—Continuity is established with NIC Access Module (Rear Transition Module). LED is on during power up.
OK	Green	On—Successful initialization of module completed. LED is off during power up and on after initialization is completed.
EXT FLT	Amber	On—One or more of the FE or GE ports is enabled, but unused. LED is on during power up.
INT FLT	Amber	On—Failure detected in the module. LED is on during power up.
Hot SWP	Blue	On—Module is ready to be removed. Illuminates after the ejector release is pressed. During hot insertion, LED is on until ejectors are locked. Off during power up.

Note

When the single-mode (long-range—80 km) GBIC module is used in the NIC Module and there is no link activity on the Gigabit Ethernet port, the LEDs GB0 and GB1 might dimly flicker. This is normal.

Chassis Rear Modules

The rear modules, in general, are designed to locate the chassis cable connections on the back of the chassis rather than the front. The rear modules primarily distribute signals between the functional modules in front and the cabling in the rear.

This section discusses the following chassis rear modules:

- NIC Access Module on page 48
- HFC Connector Module on page 50
- Switched I/O Module on page 53
- Hard Disk Module on page 55

NIC Access Module

The NIC Access Module contains a 6 U (267 mm) x 80 mm card with a 4 HP (20 mm), single-wide rear panel. The module installs from the rear of the chassis and is hot-swappable. There must be one NIC Access Module opposite each NIC Module.

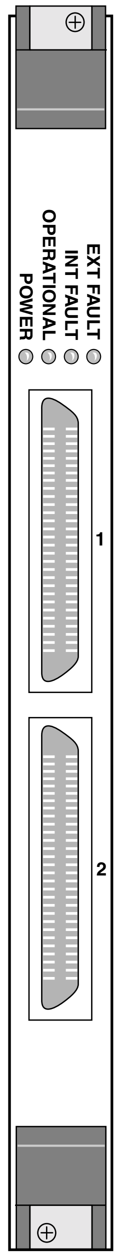
The NIC Access Module passes the network traffic through the midplane as Fast Ethernet frames to and from the NIC Module. The module has two RJ-21 connectors. A NIC Access Module cable plugs into each connector and fans out to 12 individual lines with RJ-45 connectors. Eight of the RJ-45 connectors from the NIC Access Module cable plugged into connector 1 mate with the HFC Connector Modules or SIMs within the same chassis domain. The NIC Access Module cable plugged into connector 2 provides four RJ-45 connectors that are the Fast Ethernet interfaces. See “HFC Connector Module” on page 50 and “Switched I/O Module” on page 53 for more discussion and an illustration of the data flow path.

Table 22 describes the functions of the NIC Access Module LEDs. Figure 17 on page 49 shows the NIC Access Module rear panel.

Table 22: NIC Access Module LEDs

LED	Color	Function
POWER	Green	ON—Power is applied to the module.
OPERATIONAL	Green	ON—Initialization successfully completed.
INT FAULT	Green	ON—Failure detected in the module.
EXT FAULT	Amber	ON—One or more of the Fast Ethernet or Gigabit Ethernet ports is enabled, but unused.

Figure 17: NIC Access Module Front Panel



HFC Connector Module

The HFC Connector Module contains a 6 U (267 mm) x 80 mm card with an 8 HP (40 mm), double-wide rear panel. The module installs from the rear of the chassis and is hot-swappable.

The HFC Connector Module has two RJ-45 Ethernet connectors carrying IP data to and from the network-side interface. The module also has four downstream F-connectors and four upstream F-connectors for routing traffic to and from the HFC network (see Figure 18 on page 51).

The HFC Connector Modules are located on the opposite side of the midplane from the DOCSIS Modules. These modules can occupy slots 1 through 4 and 10 through 13. There is one HFC Connector Module for each DOCSIS Module.

> **Note**
> If a NIC Module is used in a version 2 chassis, you must use a SIM opposite each DOCSIS Module to provide the Ethernet connectivity between a DOCSIS Module and a NIC Module (through the midplane). You must not use an HFC Connector Module in this configuration.

The HFC Connector Module receives downstream IP data from the 100Base-T Ethernet cables coming from the NIC Access Module. IP data is then passed to the DOCSIS Module for processing into DOCSIS frames, then into an MPEG stream. The MPEG stream is modulated onto the RF carrier signal and routed back to the HFC Connector Module (through the midplane) for downstream distribution through the F-connectors to the HFC network.

Upstream data follows the path in reverse order, starting with data coming into the upstream F-connectors. Figure 19 on page 52 shows this data flow.

Table 24 summarizes the definitions of the Fast Ethernet LEDs on the HFC Connector Module. Figure 18 on page 51 shows the HFC Connector Module rear panel.

Table 23: HFC Connector Module Fast Ethernet LEDs

LED	Function
Green	On—Link is present. Off—Link is not present. Blinking—Activity on link.
Amber	On—100Base-T mode. Off—10Base-T mode.

Figure 18: HFC Connector Module Rear Panel

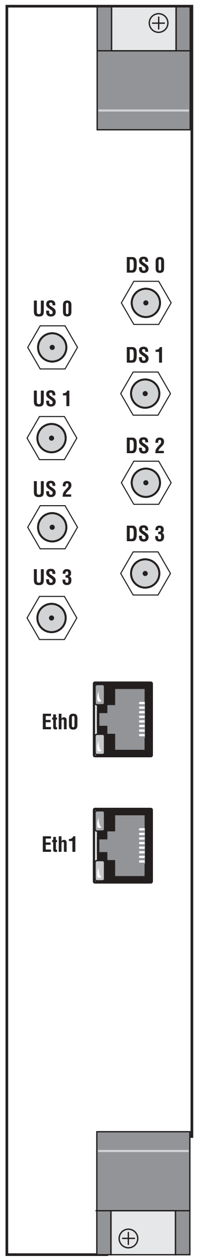
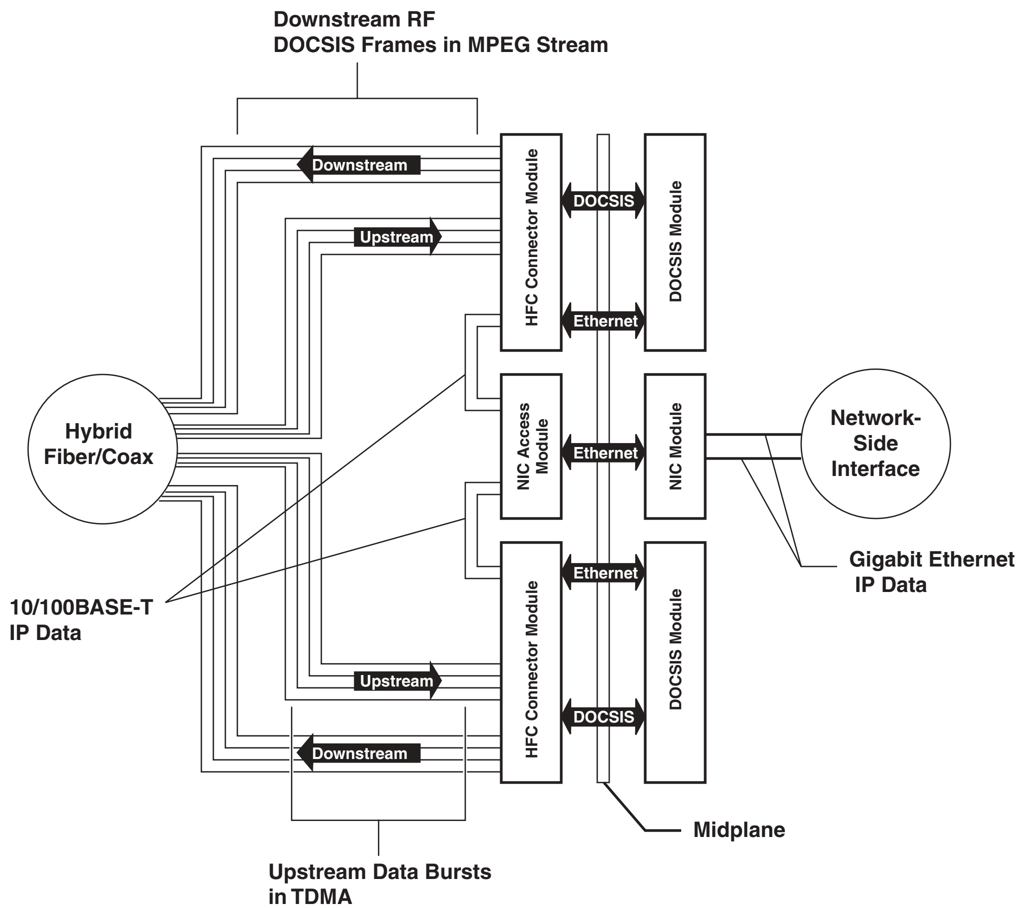


Figure 19: G10 CMTS Data Flow



Switched I/O Module

The Switched I/O Module (SIM) contains a 6 U (267 mm) x 80 mm card with an 8 HP (40 mm), double-wide rear panel. The module installs from the rear of the chassis and is hot-swappable.

The SIM has four RJ-45 Ethernet connectors, and four downstream F-connectors and eight upstream F-connectors for routing traffic to and from the HFC network (see Figure 20 on page 54).

> **Note**
>
> - Fast Ethernet ports Eth0-B and Eth1-B are not used.
> - Upstream F-connectors US4 through US7 are not used.
> - Ports DSR-IN and DSR-OUT are not used.

The SIMs are located on the opposite side of the midplane from the DOCSIS Modules. These modules can occupy slots 1 through 4 and 10 through 13. There is one SIM for each DOCSIS Module.

The SIM provides the path and switching for Ethernet frames between DOCSIS Modules and the NIC Module.

- If you have a version 1 chassis, the Ethernet path is through a NIC Access Module cable connected between the NIC Access Module and the SIM.
- If you have a version 2 chassis, the Ethernet path is through the midplane. This eliminates the need for external NIC Access Module cables.

> **Note**
>
> If a NIC Module is used in a version 2 chassis, you must use a SIM opposite each DOCSIS Module to provide the Ethernet connectivity between a DOCSIS Module and a NIC Module (through the midplane). You must not use an HFC Connector Module in this configuration.

The SIM receives downstream IP data from the NIC Access Module. IP data is then passed to the DOCSIS Module for processing into DOCSIS frames, then into an MPEG stream. The MPEG stream is modulated onto the RF carrier signal and routed back to the SIM (through the midplane) for downstream distribution through the F-connectors to the HFC network.

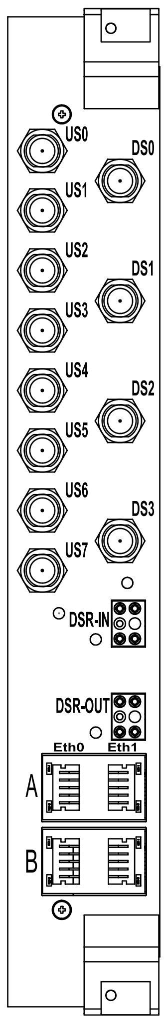
Upstream data follows the path in reverse order, starting with data coming into the upstream F-connectors. Figure 19 on page 52 shows this data flow. Also see “G10 CMTS Components” on page 8.Table 24 summarizes the definitions of the Fast Ethernet LEDs on the SIM. Figure 20 on page 54 shows the SIM rear panel.

> **Note**
>
> These LEDs can illuminate even when no cables are connected to the ports, as long as the link is present from the DOCSIS Module through the midplane.

Table 24: SIM Fast Ethernet Port LEDs

LED	Function
Green	On—Link is present. Off—Link is not present. Blinking—Activity on link.
Amber	On—100Base-T mode. Off—10Base-T mode.

Figure 20: SIM Rear Panel



Hard Disk Module

The Hard Disk Module contains a 6 U (267 mm) x 80 mm card with a 4 HP (20 mm), single-wide rear panel. The module installs from the rear of the chassis and is hot-swappable.

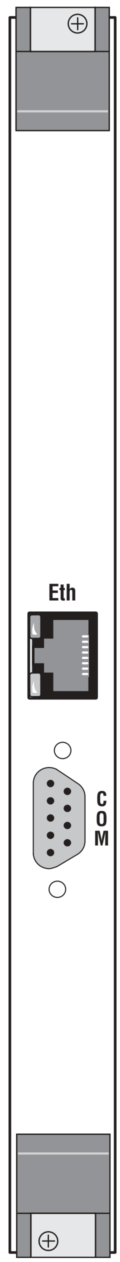
The Hard Disk Module contains the system nonvolatile memory implemented as a hard disk. There must be one Hard Disk Module for each Chassis Control Module. It installs opposite the Chassis Control Module in slot 6 or 7. The Hard Disk Module is keyed so that it can be installed only in slots 6 and 7.

The serial port COM is identical to the serial port on the Chassis Control Module and can be used as a local management port.

The Fast Ethernet port Eth is not used.

Figure 21 on page 56 shows the Hard Disk Module rear panel.

Figure 21: Hard Disk Module Rear Panel



Chapter 3
System Architecture Overview

This chapter provides an overview of the G10 CMTS's system architecture, discussing the following topics:

JUNOSg Internet Software Overview

The JUNOSg software provides Internet Protocol (IP) routing software, as well as software for interface, cable, network, and chassis management.

The software runs on the CMTS's Routing Engine. The software consists of processes that support Internet routing protocols, control the CMTS's interfaces and the CMTS chassis itself, and allow system management of the CMTS. All these processes run on top of a kernel that provides the communication among all the processes and has a direct link to the Packet Forwarding Engine software. You use the JUNOSg software to configure the routing protocols that run on the CMTS and properties of the interfaces in the CMTS. After you have activated a software configuration, you can use the software to monitor the protocol traffic passing through the CMTS and to troubleshoot protocol, network, and HFC network connectivity problems.

This section discusses the following topics to provide an overview of the components of the software and of how to use the software:

For complete information about configuring the software, including examples, see the JUNOSg software configuration guides.

Routing Engine Software Components

The Routing Engine software consists of several software processes that control router functionality and a kernel that provides the communication among all the processes. This section describes each of the Routing Engine software components:

- Routing Protocol Process on page 58
- Interface Process on page 60
- SNMP and MIB II Processes on page 60
- Management Process on page 60
- Routing Engine Kernel on page 60

Routing Protocol Process

The software routing protocol process controls the routing protocols that run on the CMTS. The routing protocol process starts all configured routing protocols and handles all routing messages. It maintains one routing table and consolidates the routing information learned from all routing protocols into this common table. From this routing information, the routing protocol process determines the active routes to network destinations and installs these routes into the Routing Engine's forwarding table. Finally, the routing protocol process implements routing policy, which allows you to control the routing information that is transferred between the routing protocols and the routing table. Using routing policy, you can filter routing information so that only some of it is transferred, and you also can set properties associated with the routes.

For complete information about the routing protocol process, including routing protocols, routing and forwarding tables, routing policy, and interfaces, see the JUNOSg software configuration guides.

Routing Protocols

The JUNOSg Internet software implements full IP routing functionality, providing support for IP Version 4 (IPv4). The routing protocols are fully interoperable with existing IP routing protocols, and provide the scale and control necessary for the Internet core. The software provides support for the following routing and traffic engineering protocols:

- OSPF—Open Shortest Path First, Version 2, is an IGP that was developed for IP networks by the Internet Engineering Task Force (IETF). OSPF is a link-state protocol that makes routing decisions based on the SPF algorithm.
- RIP—Routing Information Protocol, Version 2, is an IGP for IP networks based on the Bellman-Ford algorithm. RIP is a distance-vector protocol. The JUNOSg RIP software is compatible with RIP Version 1.
- ICMP—Internet Control Message Protocol router discovery allows hosts to discover the addresses of operational routers on the subnet.

Routing and Forwarding Tables

A primary function of the JUNOSg routing protocol process is to maintain the Routing Engine's routing table and to determine the active routes to network destinations. It then installs these routes into the Routing Engine's forwarding table. The JUNOSg kernel then copies this forwarding table to the Packet Forwarding Engine.

The routing table stores routing information for all routing protocols running on the CMTS. OSPF and RIP store their routing information in this common routing table, and you can configure additional routes, such as static routes, to be included in this routing table. OSPF and RIP use the routes in the routing table when advertising routing information to their neighbors.

Using the routing table, the routing protocol process uses the collected routing information to determine active routes to network destinations. The routing protocol process determines active routes by choosing the most preferred route, which is the route with the lowest preference value. By default, the route's preference value is simply a function of how the routing protocol process learned about the route. You can modify the default preference value using routing policy and with software configuration parameters.

Routing Policy

By default, all routing protocols place their routes into the routing table. When advertising routes, the routing protocols, by default, advertise only a limited set of routes from the routing table. Specifically, each routing protocol exports only the active routes that were learned by that protocol. In addition, IGPs (OSPF and RIP) export the direct (interface) routes for the interfaces on which the protocol is explicitly configured.

For the routing table, you can affect the routes that a protocol places into the table and the routes from the table that the protocol advertises by defining one or more routing policies and then applying them to the specific routing protocol.

Routing policies applied when the routing protocol places routes into the routing table are called *import policies* because the routes are being imported into the routing table. Policies applied when the routing protocol is advertising routes that are in the routing table are called *export policies* because the routes are being exported from the routing table. In other words, the terms import and export are used with respect to the routing table.

Routing policy allows you to control (filter) which routes are imported into the routing table and which routes are exported from the routing table. Routing policy also allows you to set the information associated with a route as it is being imported into or exported from the routing table. Applying routing policy to imported routes allows you to control the routes used to determine active routes. Applying routing policy to routes being exported from the routing table allows you to control the routes that a protocol advertises to its neighbors.

You implement routing policy by defining policies. A policy specifies the conditions to use to match a route and the action to perform on the route when a match occurs. For example, when a routing table imports routing information from a routing protocol, a routing policy might modify the route's preference or prevent the route from even being installed in a routing table. When exporting routes from a routing table into a routing protocol, a policy might assign metric values, tag the route with additional information, or prevent the route from being exported altogether. You also can define policies for redistributing the routes learned from one protocol into another protocol.

Interface Process

The JUNOSg interface process allows you to configure and control the physical interface devices and logical interfaces in the CMTS. You configure various interface properties such as the interface location (the slot in which the module is installed and the port on the module), the interface family (Layer 2 or Layer 3), and interface-specific properties. You can configure the interfaces that are currently present in the CMTS, as well as interfaces that you might be adding.

The JUNOSg interface process communicates with the interface process in the Packet Forwarding Engine through the JUNOSg kernel, enabling the JUNOSg software to track the status and condition of the CMTS's interfaces.

SNMP and MIB II Processes

The JUNOSg Internet software supports the Simple Network Management Protocol (SNMP), Versions 1, 2, and 3, which provides a mechanism for monitoring the state of the CMTS. This software is controlled by the JUNOSg SNMP and MIB II processes, which consist of an SNMP master agent and a MIB II agent.

Management Process

Within the JUNOSg software, a management process starts and monitors all the other software processes, as well as the command-line interface (CLI), which is the primary tool you use to control and monitor the JUNOSg software. The management process starts all the software processes and the CLI when the CMTS boots. If a software process terminates for some reason, the management process makes all reasonable attempts to restart it.

Routing Engine Kernel

The Routing Engine kernel provides the underlying infrastructure for all the JUNOSg software processes. It also provides the link among the routing protocol process' routing table and the Routing Engine's forwarding table. Additionally, it conducts communication with the Packet Forwarding Engine, including keeping the Packet Forwarding Engine's copy of the forwarding table synchronized with the master copy in the Routing Engine.

Tools for Accessing and Controlling the Software

The primary means of accessing and controlling the JUNOSg software is the CLI.

The CMTS provides two ports on the Chassis Control Module for connecting external management devices to the Routing Engine and hence to the JUNOSg software:

- Fast Ethernet management port (Eth0)—Connects the Routing Engine to a management LAN (or any other device that plugs into an Ethernet connection) for out-of-band management of the CMTS. The Ethernet port can be 10 or 100 Mbps and uses an autosensing RJ-45 connector.

- Console port (COM)—Connects a system console to the Routing Engine with an RS-232 serial cable.

The CLI is the interface to the JUNOSg Internet software that you use whenever you access the CMTS from the console or through a remote network connection. The CLI provides commands used to perform various tasks, including configuring the JUNOSg software, and monitoring and troubleshooting the software, network connectivity, and the CMTS hardware.

The JUNOSg CLI is a straightforward command interface. You type commands on a single line, and enter the commands by pressing the Enter key. The CLI provides command help and command completion, and also provides Emacs-style keyboard sequences that allow you to move around on a command line and scroll through a buffer that contains recently executed commands.

Software Monitoring Tools

You can monitor and troubleshoot the software, routing protocols, network connectivity, and hardware by running commands from the CLI. The CLI provides commands that let you display information in the routing table, display routing protocol-specific information, and check network connectivity using the ping and traceroute commands.

The JUNOSg software includes Simple Network Management Protocol (SNMP) software, which allows you to manage CMTSs. The SNMP software consists of an SNMP master agent and a MIB II agent, and provides full support for MIB II SNMP Version 1 traps and Version 2 and Version 3 notifications.

The software also supports tracing and logging operations, which allow you to track events that occur in the CMTS—both normal CMTS operations and error conditions—and to track the packets that are generated by or pass through the CMTS. Logging operations use a system log-like mechanism to record systemwide, high-level operations, such as interfaces going up or down and users logging into or out of the CMTS. Tracing operations record more detailed messages about the operation of routing protocols, such as the various types of routing protocol packets sent and received, and routing policy actions.

Software Installation and Upgrade Procedures

The JUNOSg software is preinstalled in the CMTS. To upgrade the software, you copy a set of software images over the network to the CMTS's flash disk using the CLI. The JUNOSg software set consists of several images that are provided in individual packages or as a single bundle. You normally upgrade all packages simultaneously. For information about installing and upgrading JUNOSg software, see the JUNOSg software configuration guides.

Data Path Processing

This section describes the data path processing of the downstream and upstream traffic flows.

Packets that enter the CMTS from the network-side interface (NSI) and are destined for the HFC network are processed through the downstream path. Packets that enter the CMTS from the HFC network and are destined to either the NSI or the HFC network are processed through the upstream path. See Figure 22 on page 64 for a graphical depiction of the data flow through the modules in a chassis.

Downstream Data Path

Following is a description of the flow of a packet through the downstream data path of a DOCSIS Module:

1. A packet is received on the Gigabit Ethernet interface of a NIC Module and is forwarded to a DOCSIS Module over a Fast Ethernet connection.

2. If you have configured and applied a subscriber management input filter, the packet is evaluated based on the filter configuration and is either dropped or passed.

3. If the packet is not dropped by the input filter, it is classified to an ingress logical interface (unit) and either bridged (Layer 2) or forwarded (Layer 3), depending on the configuration of the ingress unit, to the egress unit.

4. The packet is classified to a service flow based on its header.

5. If you have configured and applied a subscriber management or IEEE 802.1 output filter, the packet is evaluated based on the filter configuration and is either dropped or passed.

6. If the packet is not dropped by the output filter, it is sent to QoS processing, where it is ordered and scheduled based on its QoS parameters and the traffic scheduling policy you have configured. If you have configured a congestion management policy, the packet might be dropped, depending on its projected queue traversal latency.

7. The packet is transmitted to the HFC network on the physical interface associated with the egress unit.

Upstream Data Path

Following is a description of the flow of a packet through the upstream data path of a DOCSIS Module:

1. If you have configured and applied a subscriber management or IEEE 802.1 input filter, a packet received on a cable interface of a DOCSIS Module is evaluated based on the filter configuration and is either dropped or passed.

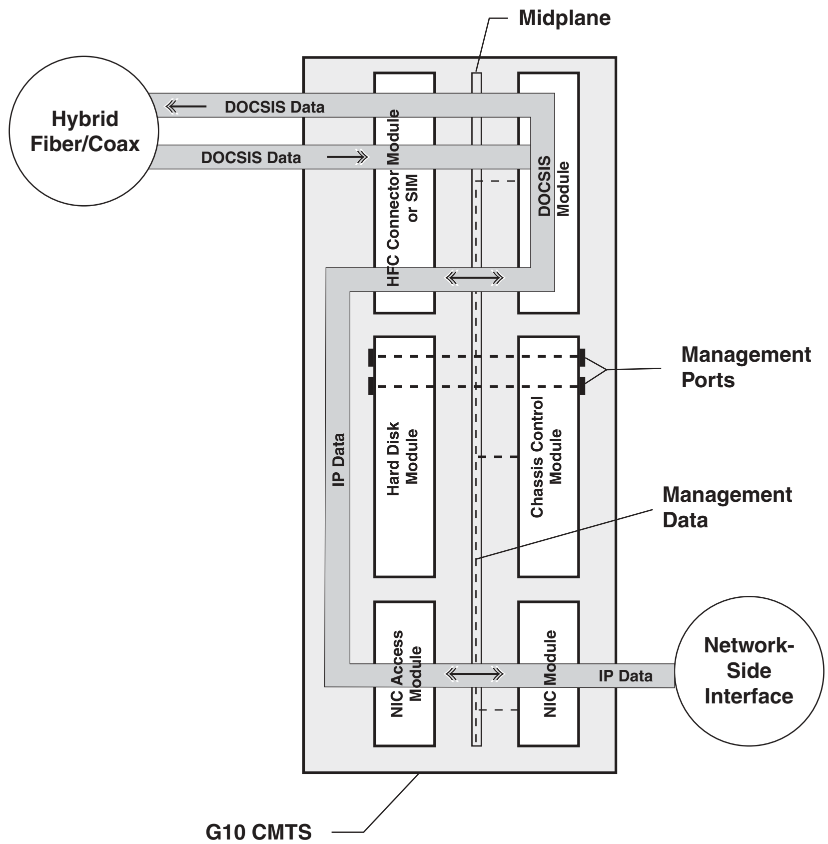
2. If the packet is not dropped by an input filter, it is classified to an ingress unit and either bridged (Layer 2) or forwarded (Layer 3), depending on the configuration of the ingress unit, to the egress unit.

3. If you have configured and applied a subscriber management or IEEE 802.1 output filter, the packet is evaluated based on the filter configuration and is either dropped or passed.

4. If the packet is not dropped by the output filter, it is sent to QoS processing, where it is ordered and scheduled based on its QoS parameters and the traffic scheduling policy you have configured. If you have configured a congestion management policy, the packet might be dropped, depending on its projected queue traversal latency.

5. The packet is transmitted to either the NSI or the HFC network on the physical interface associated with the egress unit.

Figure 22: G10 CMTS Data Flow



Part 2
Initial Installation

Chapter 4
Prepare the Site

This chapter provides the installation site requirements and step-by-step procedures that we recommend in preparation for the installation of the G10 CMTS in the headend. The installation procedures described in this manual assume that the procedures and the checklist provided in this chapter have been successfully completed and approved by the user and Juniper Networks field engineers.

All the steps required to successfully install the G10 CMTS are summarized at the end of this chapter in Table 38 on page 90.

The topics in this chapter include:

Safety Precautions

> **Caution**
>
> During the preparation and installation of the G10 CMTS, we strongly recommend that you adhere to the precautions presented in this section to avoid physical injury due to lifting, moving, or rack mounting the CMTS.

- Only trained and certified personnel should be involved in the installation of the CMTS.
- We recommend the use of a lift to install the G10 CMTS.
- Do not attempt to lift the G10 CMTS alone. If a lift is not used, we recommend at least three installers assist with lifting the system. This includes removal from the shipping carton, temporary or permanent placement on a flat surface, rack mounting, or lifting for any other purpose.
- Prior to lifting and moving the G10 CMTS, ensure that the path you will be taking is totally unobstructed.
- To avoid back injury when lifting the G10 CMTS, avoid bending your back to achieve lift leverage. Instead, keep your back in the upright position, and bend at the knees. Also avoid twisting your back while lifting.
- Always rack mount a system from the bottom up to maintain the lowest possible center of gravity of the entire rack with its equipment.
- Do not install any additional modules or power supplies to the G10 CMTS prior to mounting it in a rack. First mount the system into the rack with its original contents as shipped, then install additional components after the G10 CMTS is securely mounted to its rack.
- Never attempt to move the G10 CMTS while any cables or power cords are still connected.
- Ensure that any loose articles of clothing are well clear of the fan trays prior to powering up the G10 CMTS.

> **Warning**
>
> During the preparation and installation of the G10 CMTS, we strongly recommend that you adhere to the precautions presented in this section to avoid physical injury due to an electrical hazard.

> **Warning**
>
> High levels of electrical energy are distributed across the system midplane. Be careful not to contact the midplane connectors, or any component connected to the midplane, with any metallic object while hot-swapping or servicing components installed in the system.

- We recommend at least two installers be present when connecting the G10 CMTS to its power source.

- Remove all jewelry that can act as a conductor of electricity such as watches, rings, bracelets, and necklaces.
- Prior to making any power connections, locate the emergency power-off switch and ensure that the path between where the G10 CMTS will be installed and the power-off switch is unobstructed.
- Prior to making any power connections, survey the immediate area to ensure that no additional electrical safety hazards exist (such as ungrounded equipment or power cords, or damp, moist areas that could conduct electricity).
- Ensure that the power supply switches on the rear of the G10 CMTS are in the OFF (O) position prior to connecting any power cords.
- Use the factory-supplied AC power cords. These cords are grounded and appropriately rated for the G10 CMTS.
- Use the factory-supplied DC power cord ring lugs, and wire according to your local code for the DC power cord connection to the G10 CMTS.
- Attach all power cords to their appropriate terminals (AC or DC) in the rear of the G10 CMTS prior to plugging any power cord into its respective power source (AC or DC).
- Never apply excessive force when attaching a power cord to a terminal or power source if it does not readily mate with ease. Having to apply an unusual amount of force might indicate that electrical leads are bent and damaged, or that an improper connection is being attempted.
- Ensure that the G10 CMTS chassis is properly grounded to earth prior to connecting any source of power. See “Ground the Chassis” on page 94 for more details.

> **Caution**
>
> During the preparation and installation of the G10 CMTS, we strongly recommend that you adhere to the precautions presented in this section to avoid damaging the G10 CMTS.

- Before handling any G10 CMTS module, always wear an ESD ground strap that is connected to the ESD strap jack located on the front of the chassis.
- Leave all modules in the anti-static bags they are shipped in until you are ready to install the modules into the G10 CMTS.
- Handle all modules by their card edges or ejectors and avoid directly touching any component on a module.
- Ensure that all modules and power supplies are properly aligned and mated to their respective midplane connectors prior to powering up the G10 CMTS. Check that all captive retainer screws are securely tightened according to the torque specifications provided herein.
- Air management modules and air management panels must always be installed in empty slots while operating the G10 CMTS to ensure that proper air ventilation occurs throughout the chassis, and to reduce electromagnetic interference (EMI) emissions.

- All modules and power supplies are designed to smoothly slide into the G10 CMTS chassis using the card guides. Do not apply excessive force during the insertion of any assembly into the system. If resistance to insertion is encountered while installing any assembly, carefully remove it, realign its card edge with the chassis' card guides, and reinsert it into the system.

- When you install a rear chassis module, apply more pressure to the upper ejector than to the lower ejector. This ensures the module connectors on the top of the card edge are properly aligned with the midplane connectors. The bottom edge has no connectors, so you do not need to press the rear ejector as firmly.

- Do not operate the G10 CMTS without the front and rear fan trays that are shipped with the system.

- Do not apply torque to screws that is below or above the specifications provided herein.

Notices

Warning

- This equipment is intended only for installation in a restricted access location within a building.
- This equipment is intended for indoor use only.
- This equipment does not have a direct copper connection to the outside plant.
- Removal of power supplies or cards will result in access to hazardous energy.
- Each power cord must be connected to an independent branch circuit.
- Product connected to two power sources. Disconnect both power sources before servicing.

Caution

Risk of explosion if battery is replaced by an incorrect type. Dispose of used batteries according to the instructions.

Caution

This is a Class A product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

Note

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:
(1) This device may not cause harmful interference, and
(2) this device must accept any interference received, including interference that may cause undesired operation.

Power

The G10 CMTS can be configured with either AC or DC power supply modules. To support a fully-populated CMTS, the installation site must be able to source 1500 watts of input power.

Note

The G10 CMTS chassis midplane is electrically partitioned into A and B domains. To support power redundancy, you must supply power from different circuits to each power transition module to implement power source redundancy.

Warning

Ensure that all power distribution panel switches on the rear of the CMTS are in the off position prior to connecting any electrical power cords. Also ensure that the CMTS chassis is properly grounded to earth prior to connecting any source of power.

AC Power

The G10 CMTS requires an AC power source that operates within a voltage and frequency range of 100 to 240 VAC and 47 to 63 Hz. In addition, appropriately sized circuit protection measures must be implemented to ensure compliance with electrical regulatory standards.

Use the factory-supplied power cords for AC power.

Caution

AC power sources must use circuit breakers, rather than fuses, for current surge protection.

DC Power

The G10 CMTS requires a DC power source that operates within a voltage range of –36 to –75 VDC. Unlike the AC configuration, the DC power transition modules do not operate independently. Each DC power transition module supports the power supplies in both domains of the chassis. If one DC power transition module fails, all the current for the system must be supplied from a single power source. Therefore, within the United States, a 50 A circuit breaker (36 A maximum, plus margin) must be used with each of the two independent DC power sources connected to the CMTS. Outside the United States, each DC power source must have circuit breaker protection to account for a maximum current of 36 A, plus additional margin required by local regulations.

Use the factory-supplied DC power cord ring lugs, and wire according to your local code for the DC power cord connection to the G10 CMTS.

Environment

The installation site must meet the specifications provided in Table 25 to maintain the proper environmental conditions for the G10 CMTS.

Table 25: G10 CMTS Environmental Specifications

Parameter	Condition	Requirement
Temperature	Ambient operating	0° to +40°C (0° to +104°F)
	Ambient non-operating	–35° to +60°C (–31° to +140°F)
Humidity	Ambient operating and non-operating	10% to 90% (non-condensing)
Altitude	Operating and non-operating	0 to 3048 m (10,000 ft)
Vibration	Operating	5 Hz to 200 Hz, at 1.0g (1.0 oct/min)
	Non-operating	5 Hz to 200 Hz, at 1.0g (1.0 oct/min) 200 Hz to 500 Hz, at 2.0g (1.0 oct/min)

Mounting

The G10 CMTS can be mounted in a 19-inch EIA RS-310-C equipment rack or a 23-inch AT&T DATAPHONE equipment rack. You can install the CMTS into non-standard racks by using the additional rail mounting bracket holes in the CMTS.

> **Note**
>
> We recommend that you rack mount systems from the bottom up to maintain the lowest possible center of gravity of the entire rack with its equipment.

> **Caution**
>
> We recommend that you use an equipment shelf or tray beneath the CMTS to support its weight. The shelf avoids backward toppling of the rack and excess torque on the mounting brackets.

We recommend you use a cable organizer to assist with the routing of cables to and from the equipment rack. You should mount the cable organizer after the CMTS is installed.

For thermal management, airflow enters into the lower front and sides of the CMTS chassis and exits through the upper rear. As a result, a clearance of 3 to 6 inches is required on each side of the CMTS. You can mount additional equipment directly on either the top or the bottom of the CMTS without impacting system ventilation.

> **Caution**
>
> We recommend that you locate neighboring equipment such that its ventilation exhaust does not feed into the CMTS air intakes.

We recommend that you maintain proper clearance to the front and rear of the mounting rack so that the CMTS can be easily accessed during maintenance. The recommended clearance to the front and rear of the chassis is 3 feet and 2 feet.

Tools and Equipment Required for Installation

You need the following tools to complete the G10 CMTS installation:

- M2.5 Phillips torque screwdriver
- M2.5 flathead torque screwdriver
- M3 Phillips torque screwdriver
- M5 Phillips torque screwdriver
- #10 Phillips torque screwdriver
- #10 flathead torque screwdriver
- #12 Phillips torque screwdriver
- 7/16 in. torque wrench
- 22-10 AWG crimper/cutter/stripper

In addition, you might need the following supplies:

- RF cables and adapters
- Ethernet cables with RJ-45 connectors

You need the following equipment to configure the G10 CMTS and verify that the RF system has been set up properly:

- PC with asynchronous terminal emulation
- RF spectrum analyzer
- RF power meter

Coaxial Cable Requirements

To achieve optimal RF performance and to minimize the potential damage of the F-connectors on the HFC Connector Modules and SIMs, we recommend that you use the coaxial cable types listed in Table 26.

Table 26: Coaxial Cable Requirements

Cable Type	Diameter of Center Conductor
RG-59/U	0.57 mm (0.022 in)
RG-59	0.86 mm (0.034 in)
RG-6	1.05 mm (0.041 in)

You can use any of the cable types listed in Table 26 initially. However, if a cable in a particular F-connector is replaced, we recommend that the you replace it with a cable that has the same, or larger, center conductor diameter than the original cable. This ensures that proper contact between the cable conductor and an F-connector is maintained.

If a replacement cable has a smaller center conductor diameter than the original cable—for example, replacing an RG-6 cable with an RG-59U—the smaller RG-59U cable conductor might not make adequate contact with an F-connector, which can potentially lead to a partial or complete loss of the signal.

Characterization of Installation Site

You need to characterize several parameters associated with the installation site prior to the installation of the CMTS. These parameters relate to specific aspects of the installation site system, HFC network connections, and CMTS downstream and upstream transmissions. The information collected allows field engineers to verify that the installation site environment is compatible with the G10 CMTS. Table 27 is provided to collect information regarding the RF plant and HFC environment.

Table 27: RF Plant/HFC Environment Characterization

Parameter	Value
Plant architecture type	____ HFC ____ All Coax
Number of optical links within HFC	
Distance between optical links within HFC	____ max ____ average
Amplifier cascade depth from node	____ max ____ average
Homes passed per node	____ max ____ average
Total homes passed by installation site	
Node combining ratio per port	___:1 upstream ___:1 downstream
Average upstream noise measurement (see note below)	____ dB
Peak upstream noise measurement (see note below)	____ dB
Passive loss from upstream receiver to CMTS	____ dB
Maximum tap value used	____ dB
Maximum tap output level at highest frequency	____ dBmV
Maximum drop loss allowed from tap to home	____ dB
Method used for return path alignment	
DOCSIS services offered? If yes, complete Table 28 on page 77.	____ yes ____ no
Upstream frequency spectrum utilization	(complete Table 31 on page 81)

Note

We recommend that you take a sample of 10 percent of the total nodes terminated at the installation site for average and peak noise measurements using the methodology described in “Noise Measurement Methodology” on page 83.

Table 28 is provided to collect information regarding the existing DOCSIS services supported by the installation site. If there are no existing DOCSIS services supported, skip Table 28 and proceed to subsequent tables. If more than two DOCSIS services exist, additional tables are provided in “Additional Characterization Tables” on page 85.

Table 28: Existing DOCSIS Service Characterization

Parameter	Value
1st DOCSIS Service	
Upstream RF bandwidth allocated	____ MHz (max) ____ MHz (min)
Upstream modulation type	____ QPSK ____ 16QAM
Upstream input level expected at CMTS	____ dBmV
FEC enabled? If yes, FEC level parameters (T and K)	____ yes ____ no ____T ____ K
Upstream measured C/N	____ dB
Downstream RF bandwidth allocated	____ MHz (max) ____ MHz (min)
Downstream modulation type	____ 64QAM ____256QAM
Downstream output signal level (relative to analog video)	____ dB
Downstream measured C/N	____ dB (DOSCIS carrier) ____ dB (Analog video carrier)
Downstream interleave depth setting	___ (# of taps) ____(increments)
2nd DOCSIS Service	
Upstream RF bandwidth allocated	____ MHz (max) ____ MHz (min)
Upstream modulation type	____ QPSK ____ 16QAM
Upstream input level expected at CMTS	____ dBmV
FEC enabled? If yes, FEC level parameters (T and K)	____ yes ____ no ____ T ____ K
Upstream measured C/N	____ dB
Downstream RF bandwidth allocated	____ MHz (max) ____ MHz (min)
Downstream modulation type	____ 64QAM ____256QAM
Downstream output signal level (relative to analog video)	____ dB
Downstream measured C/N	____ dB (DOCSIS carrier) ____ dB (Analog video carrier)
Downstream interleave depth setting	___ (# of taps) ____(increments)

Table 29 on page 78 and Table 30 on page 80 are provided to collect upstream and downstream characterization information for a DOCSIS Module. If the CMTS configuration includes more than one DOCSIS Module, additional tables are provided in "Additional Characterization Tables" on page 85.

Table 29: Upstream CMTS Parameter Characterization

Upstream Parameters	Port 0	Port 1	Port 2	Port 3
DOCSIS Module #___				
Node combining ratio per port	____ : 1	____ : 1	____ : 1	____ : 1
Expected interfaces per port				
Expected port input level	____ dBmV	____ dBmV	____ dBmV	____ dBmV
Modulation type (where applicable)	_ QPSK _ 16QAM (CH0) _ QPSK _ 16QAM (CH1) _ QPSK _ 16QAM (CH2) _ QPSK _ 16QAM (CH3) _ QPSK _ 16QAM (CH4) _ QPSK _ 16QAM (CH5) _ QPSK _ 16QAM (CH6) _ QPSK _ 16QAM (CH7) _ QPSK _ 16QAM (CH8) _ QPSK _ 16QAM (CH9) _ QPSK _ 16QAM (CH10) _ QPSK _ 16QAM (CH11) _ QPSK _ 16QAM (CH12) _ QPSK _ 16QAM (CH13) _ QPSK _ 16QAM (CH14) _ QPSK _ 16QAM (CH15)	_ QPSK _ 16QAM (CH0) _ QPSK _ 16QAM (CH1) _ QPSK _ 16QAM (CH2) _ QPSK _ 16QAM (CH3) _ QPSK _ 16QAM (CH4) _ QPSK _ 16QAM (CH5) _ QPSK _ 16QAM (CH6) _ QPSK _ 16QAM (CH7) _ QPSK _ 16QAM (CH8) _ QPSK _ 16QAM (CH9) _ QPSK _ 16QAM (CH10) _ QPSK _ 16QAM (CH11) _ QPSK _ 16QAM (CH12) _ QPSK _ 16QAM (CH13) _ QPSK _ 16QAM (CH14) _ QPSK _ 16QAM (CH15)	_ QPSK _ 16QAM (CH0) _ QPSK _ 16QAM (CH1) _ QPSK _ 16QAM (CH2) _ QPSK _ 16QAM (CH3) _ QPSK _ 16QAM (CH4) _ QPSK _ 16QAM (CH5) _ QPSK _ 16QAM (CH6) _ QPSK _ 16QAM (CH7) _ QPSK _ 16QAM (CH8) _ QPSK _ 16QAM (CH9) _ QPSK _ 16QAM (CH10) _ QPSK _ 16QAM (CH11) _ QPSK _ 16QAM (CH12) _ QPSK _ 16QAM (CH13) _ QPSK _ 16QAM (CH14) _ QPSK _ 16QAM (CH15)	_ QPSK _ 16QAM (CH0) _ QPSK _ 16QAM (CH1) _ QPSK _ 16QAM (CH2) _ QPSK _ 16QAM (CH3) _ QPSK _ 16QAM (CH4) _ QPSK _ 16QAM (CH5) _ QPSK _ 16QAM (CH6) _ QPSK _ 16QAM (CH7) _ QPSK _ 16QAM (CH8) _ QPSK _ 16QAM (CH9) _ QPSK _ 16QAM (CH10) _ QPSK _ 16QAM (CH11) _ QPSK _ 16QAM (CH12) _ QPSK _ 16QAM (CH13) _ QPSK _ 16QAM (CH14) _ QPSK _ 16QAM (CH15)
Channel width (where applicable) Circle the applicable unit.	____ kHz/MHz (CH 0) ____ kHz/MHz (CH 1) ____ kHz/MHz (CH 2) ____ kHz/MHz (CH 3) ____ kHz/MHz (CH 4) ____ kHz/MHz (CH 5) ____ kHz/MHz (CH 6) ____ kHz/MHz (CH 7) ____ kHz/MHz (CH 8) ____ kHz/MHz (CH 9) ____ kHz/MHz (CH 10) ____ kHz/MHz (CH 11) ____ kHz/MHz (CH 12) ____ kHz/MHz (CH 13) ____ kHz/MHz (CH 14) ____ kHz/MHz (CH 15)	____ kHz/MHz (CH 0) ____ kHz/MHz (CH 1) ____ kHz/MHz (CH 2) ____ kHz/MHz (CH 3) ____ kHz/MHz (CH 4) ____ kHz/MHz (CH 5) ____ kHz/MHz (CH 6) ____ kHz/MHz (CH 7) ____ kHz/MHz (CH 8) ____ kHz/MHz (CH 9) ____ kHz/MHz (CH 10) ____ kHz/MHz (CH 11) ____ kHz/MHz (CH 12) ____ kHz/MHz (CH 13) ____ kHz/MHz (CH 14) ____ kHz/MHz (CH 15)	____ kHz/MHz (CH 0) ____ kHz/MHz (CH 1) ____ kHz/MHz (CH 2) ____ kHz/MHz (CH 3) ____ kHz/MHz (CH 4) ____ kHz/MHz (CH 5) ____ kHz/MHz (CH 6) ____ kHz/MHz (CH 7) ____ kHz/MHz (CH 8) ____ kHz/MHz (CH 9) ____ kHz/MHz (CH 10) ____ kHz/MHz (CH 11) ____ kHz/MHz (CH 12) ____ kHz/MHz (CH 13) ____ kHz/MHz (CH 14) ____ kHz/MHz (CH 15)	____ kHz/MHz (CH 0) ____ kHz/MHz (CH 1) ____ kHz/MHz (CH 2) ____ kHz/MHz (CH 3) ____ kHz/MHz (CH 4) ____ kHz/MHz (CH 5) ____ kHz/MHz (CH 6) ____ kHz/MHz (CH 7) ____ kHz/MHz (CH 8) ____ kHz/MHz (CH 9) ____ kHz/MHz (CH 10) ____ kHz/MHz (CH 11) ____ kHz/MHz (CH 12) ____ kHz/MHz (CH 13) ____ kHz/MHz (CH 14) ____ kHz/MHz (CH 15)

Upstream Parameters	Port 0	Port 1	Port 2	Port 3
FEC enabled? If yes, FEC level parameters	_____ yes _____ no ____ T ____ K (CH 0) ____ T ____ K (CH 1) ____ T ____ K (CH 2) ____ T ____ K (CH 3) ____ T ____ K (CH 4) ____ T ____ K (CH 5) ____ T ____ K (CH 6) ____ T ____ K (CH 7) ____ T ____ K (CH 8) ____ T ____ K (CH 9) ____ T ____ K (CH 10) ____ T ____ K (CH 11) ____ T ____ K (CH 12) ____ T ____ K (CH 13) ____ T ____ K (CH 14) ____ T ____ K (CH 15)	_____ yes _____ no ____ T ____ K (CH 0) ____ T ____ K (CH 1) ____ T ____ K (CH 2) ____ T ____ K (CH 3) ____ T ____ K (CH 4) ____ T ____ K (CH 5) ____ T ____ K (CH 6) ____ T ____ K (CH 7) ____ T ____ K (CH 8) ____ T ____ K (CH 9) ____ T ____ K (CH 10) ____ T ____ K (CH 11) ____ T ____ K (CH 12) ____ T ____ K (CH 13) ____ T ____ K (CH 14) ____ T ____ K (CH 15)	_____ yes _____ no ____ T ____ K (CH 0) ____ T ____ K (CH 1) ____ T ____ K (CH 2) ____ T ____ K (CH 3) ____ T ____ K (CH 4) ____ T ____ K (CH 5) ____ T ____ K (CH 6) ____ T ____ K (CH 7) ____ T ____ K (CH 8) ____ T ____ K (CH 9) ____ T ____ K (CH 10) ____ T ____ K (CH 11) ____ T ____ K (CH 12) ____ T ____ K (CH 13) ____ T ____ K (CH 14) ____ T ____ K (CH 15)	_____ yes _____ no ____ T ____ K (CH 0) ____ T ____ K (CH 1) ____ T ____ K (CH 2) ____ T ____ K (CH 3) ____ T ____ K (CH 4) ____ T ____ K (CH 5) ____ T ____ K (CH 6) ____ T ____ K (CH 7) ____ T ____ K (CH 8) ____ T ____ K (CH 9) ____ T ____ K (CH 10) ____ T ____ K (CH 11) ____ T ____ K (CH 12) ____ T ____ K (CH 13) ____ T ____ K (CH 14) ____ T ____ K (CH 15)
Interface frequency (where applicable)	____ MHz (CH 0) ____ MHz (CH 1) ____ MHz (CH 2) ____ MHz (CH 3) ____ MHz (CH 4) ____ MHz (CH 5) ____ MHz (CH 6) ____ MHz (CH 7) ____ MHz (CH 8) ____ MHz (CH 9) ____ MHz (CH 10) ____ MHz (CH 11) ____ MHz (CH 12) ____ MHz (CH 13) ____ MHz (CH 14) ____ MHz (CH 15)	____ MHz (CH 0) ____ MHz (CH 1) ____ MHz (CH 2) ____ MHz (CH 3) ____ MHz (CH 4) ____ MHz (CH 5) ____ MHz (CH 6) ____ MHz (CH 7) ____ MHz (CH 8) ____ MHz (CH 9) ____ MHz (CH 10) ____ MHz (CH 11) ____ MHz (CH 12) ____ MHz (CH 13) ____ MHz (CH 14) ____ MHz (CH 15)	____ MHz (CH 0) ____ MHz (CH 1) ____ MHz (CH 2) ____ MHz (CH 3) ____ MHz (CH 4) ____ MHz (CH 5) ____ MHz (CH 6) ____ MHz (CH 7) ____ MHz (CH 8) ____ MHz (CH 9) ____ MHz (CH 10) ____ MHz (CH 11) ____ MHz (CH 12) ____ MHz (CH 13) ____ MHz (CH 14) ____ MHz (CH 15)	____ MHz (CH 0) ____ MHz (CH 1) ____ MHz (CH 2) ____ MHz (CH 3) ____ MHz (CH 4) ____ MHz (CH 5) ____ MHz (CH 6) ____ MHz (CH 7) ____ MHz (CH 8) ____ MHz (CH 9) ____ MHz (CH 10) ____ MHz (CH 11) ____ MHz (CH 12) ____ MHz (CH 13) ____ MHz (CH 14) ____ MHz (CH 15)
Required interface input level (where applicable)	____ dBmV (CH 0) ____ dBmV (CH 1) ____ dBmV (CH 2) ____ dBmV (CH 3) ____ dBmV (CH 4) ____ dBmV (CH 5) ____ dBmV (CH 6) ____ dBmV (CH 7) ____ dBmV (CH 8) ____ dBmV (CH 9) ____ dBmV (CH 10) ____ dBmV (CH 11) ____ dBmV (CH 12) ____ dBmV (CH 13) ____ dBmV (CH 14) ____ dBmV (CH 15)	____ dBmV (CH 0) ____ dBmV (CH 1) ____ dBmV (CH 2) ____ dBmV (CH 3) ____ dBmV (CH 4) ____ dBmV (CH 5) ____ dBmV (CH 6) ____ dBmV (CH 7) ____ dBmV (CH 8) ____ dBmV (CH 9) ____ dBmV (CH 10) ____ dBmV (CH 11) ____ dBmV (CH 12) ____ dBmV (CH 13) ____ dBmV (CH 14) ____ dBmV (CH 15)	____ dBmV (CH 0) ____ dBmV (CH 1) ____ dBmV (CH 2) ____ dBmV (CH 3) ____ dBmV (CH 4) ____ dBmV (CH 5) ____ dBmV (CH 6) ____ dBmV (CH 7) ____ dBmV (CH 8) ____ dBmV (CH 9) ____ dBmV (CH 10) ____ dBmV (CH 11) ____ dBmV (CH 12) ____ dBmV (CH 13) ____ dBmV (CH 14) ____ dBmV (CH 15)	____ dBmV (CH 0) ____ dBmV (CH 1) ____ dBmV (CH 2) ____ dBmV (CH 3) ____ dBmV (CH 4) ____ dBmV (CH 5) ____ dBmV (CH 6) ____ dBmV (CH 7) ____ dBmV (CH 8) ____ dBmV (CH 9) ____ dBmV (CH 10) ____ dBmV (CH 11) ____ dBmV (CH 12) ____ dBmV (CH 13) ____ dBmV (CH 14) ____ dBmV (CH 15)

Table 30: Downstream CMTS Parameter Characterization

Downstream Parameters	Port 0	Port 1	Port 2	Port 3
DOCSIS Module #___				
Node combining ratio per port	____ : 1	____ : 1	____ : 1	____ : 1
Interface frequency allocated	____ MHz	____ MHz	____ MHz	____ MHz
Modulation type	_ 64QAM _256QAM	_ 64QAM _256QAM	_ 64QAM _256QAM	_ 64QAM _256QAM
Output signal level (relative to analog video)	____ dB	____ dB	____ dB	____ dB
Required interface output level	____ dBmV	____ dBmV	____ dBmV	____ dBmV
Interleave depth setting	___ [I] (# of taps) ___ [J] (increments)	___ [I] (# of taps) ___ [J] (increments)	___ [I] (# of taps) ___ [J] (increments)	___ [I] (# of taps) ___ [J] (increments)

Table 31: Upstream Frequency Spectrum Utilization

Frequency	Description of Utilization	Frequency	Description of Utilization
5 – 6 MHz		24 – 25 MHz	
6 – 7 MHz		25 – 26 MHz	
7 – 8 MHz		26 – 27 MHz	
8 – 9 MHz		27 – 28 MHz	
9 – 10 MHz		28 – 29 MHz	
10 – 11 MHz		29 – 30 MHz	
11 – 12 MHz		30 – 31 MHz	
12 – 13 MHz		31 – 32 MHz	
13 – 14 MHz		32 – 33 MHz	
14 – 15 MHz		33 – 34 MHz	
15 – 16 MHz		34 – 35 MHz	
16 – 17 MHz		35 – 36 MHz	
17 – 18 MHz		36 – 37 MHz	
18 – 19 MHz		37 – 38 MHz	
19 – 20 MHz		38 – 39 MHz	
20 – 21 MHz		39 – 40 MHz	
21 – 22 MHz		40 – 41 MHz	
22 – 23 MHz		41 – 42 MHz	
23 – 24 MHz			

Summary Checklist

Table 32 provides a summary checklist of the pre-installation requirements. You should complete and review this checklist with field engineers to ensure the installation site is prepared for installing the G10 CMTS.

Table 32: Pre-Installation Requirement Summary Checklist

Requirement	Verified
Safety	
Grounding straps provided for ESD protection	
Compliance verified with all local and national regulatory requirements	
Equipment to be positioned in a clear, dry, dust-free area	
Power	
AC Power	
AC-input supply operates within range of 100 to 240 VAC and 47 to 63 Hz	
Appropriate circuit protection in place for compliance with area electric regulations	
Separate AC-input power supply sources for CMTS A and B domains	
DC Power	
DC-input supply operates within range of –36 to –75 VDC	
Appropriate circuit protection in place for compliance with area electric regulations	
Separate DC-input power supply sources for CMTS A and B domains	
Environment	
Ambient temperature conditions satisfied	
Ambient humidity conditions satisfied	
Altitude conditions satisfied	
Vibration conditions satisfied	
Mounting	
19-inch rack, 23-inch rack, or appropriate non-standard rack or shelf available	
Cable organizer available for mounting rack	
Adequate access clearance to front, rear, and sides of CMTS	
Hardware	
Specified tools and supplies available	
Test equipment available for installation and verifying RF setup	
Installation Site	
Characterization of RF Plant/HFC environment parameters completed	
Characterization of existing DOCSIS services completed	
Characterization of upstream CMTS parameters completed	
Characterization of downstream CMTS parameters completed	

Noise Measurement Methodology

This section describes the methodology for conducting average and peak upstream noise measurements. The procedures establish a consistent methodology for obtaining the requested information during the characterization of the installation site. We recommend you use the HP 8591C spectrum analyzer for taking these measurements.

Average Upstream Noise Measurement

This section defines a procedure for taking the average upstream noise measurements required as part of the RF plant and HFC environment characterization. We recommend that you take a sample of 10 percent of the nodes terminated at the installation site. Table 33 provides the appropriate setup configuration settings for the HP 8591C spectrum analyzer.

Table 33: Average Noise Spectrum Analyzer Settings

Setting	Value
Start frequency	2 MHz
Stop frequency	45 MHz
Resolution bandwidth	100 kHz
Video bandwidth	30 kHz
Scale	5 dB/div
Internal amplifier	On
Attenuator	0 dB
Reference level offset	-28 dB
Reference level	-5 dBmV
Number of averages	100

Note

You might need to adjust the reference level for your particular test environment.

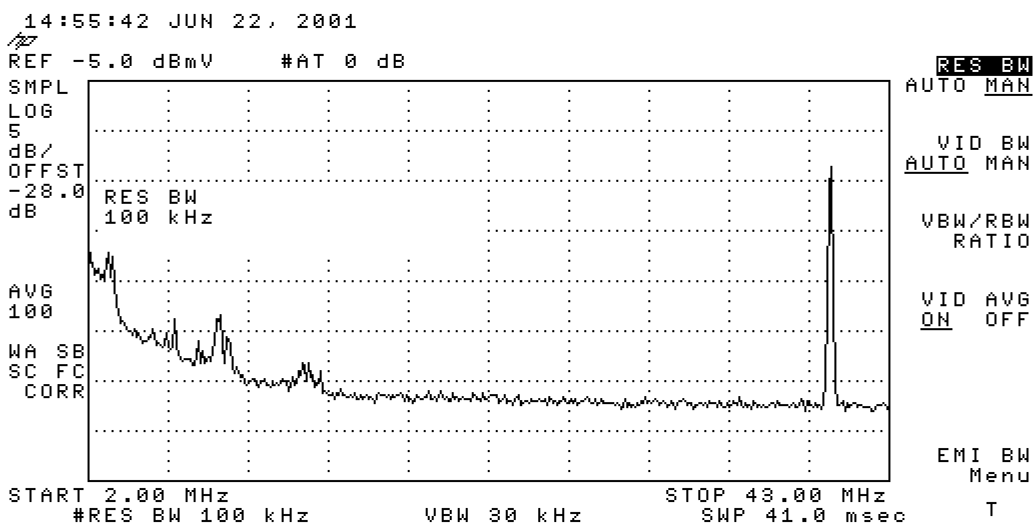
1. Connect the spectrum analyzer to the selected upstream signal at the upstream splitter or at the CMTS upstream port.

2. Configure the spectrum analyzer using the values defined in Table 33.

3. Start the measurement.

After completing the measurement, the analyzer display should resemble Figure 23 on page 84.

Figure 23: Average Upstream Noise Measurement Example



Peak Upstream Noise Measurement

This section defines a procedure for taking the peak upstream noise measurements required as part of the RF plant and HFC environment characterization. We recommend that you take a sample of 10 percent of the nodes terminated at the installation site. Table 34 provides the appropriate setup configuration settings for the HP 8591C spectrum analyzer.

Table 34: Peak Noise Spectrum Analyzer Setup

Setting	Value
Start frequency	2 MHz
Stop frequency	45 MHz
Resolution bandwidth	100 kHz
Video bandwidth	30 kHz
Scale	5 dB/div
Internal amplifier	Off
Attenuator	0 dB
Reference level of headend	0 dBmV
Max Hold	1 minute

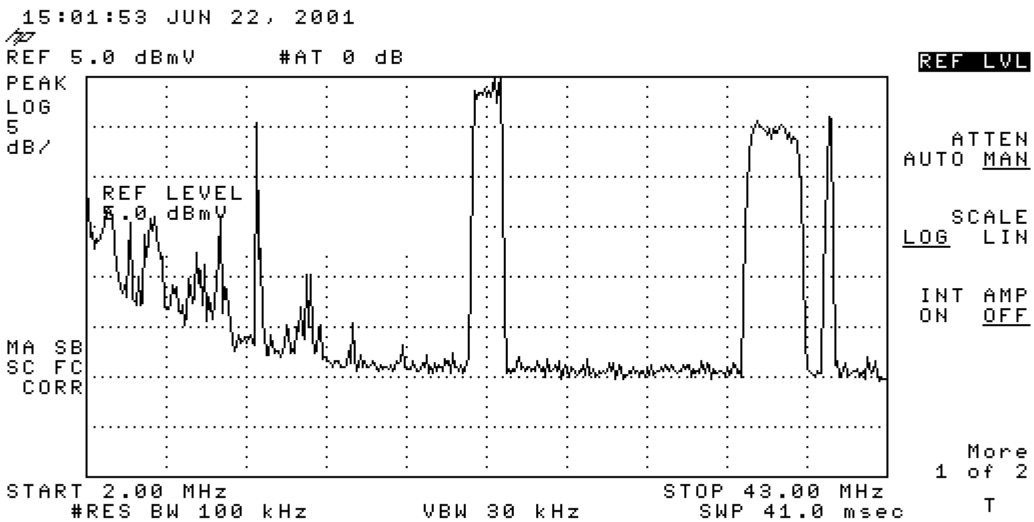
1. Connect the spectrum analyzer to the selected upstream signal at the upstream splitter or at the CMTS upstream port.

2. Configure the spectrum analyzer using the values defined in Table 34.

3. Start the measurement.

After completing the measurement, the analyzer display should resemble Figure 24 on page 85.

Figure 24: Peak Upstream Noise Measurement Example



Additional Characterization Tables

If the installation site supports more than two DOCSIS services, you can record the characterization of the additional services in Table 35. In addition, if the CMTS configuration includes more than one DOCSIS Module, you can use Table 36 and Table 37 to record the data.

Table 35: Existing DOCSIS Service Characterization

Parameter	Value
____ DOCSIS Service	
Upstream RF bandwidth allocated	____ MHz (max) ____ MHz (min)
Upstream modulation type	____ QPSK ____ 16QAM
Upstream input level expected at CMTS	____ dBmV
FEC enabled? If yes, FEC level parameters (T and K)	____ yes ____ no ____T ____ K
Upstream measured C/N	____ dB
Downstream RF bandwidth allocated	____ MHz (max) ____ MHz (min)
Downstream modulation type	____ 64QAM ____256QAM
Downstream output signal level (relative to analog video)	____ dB
Downstream measured C/N	____ dB (DOSCIS carrier) ____ dB (Analog video carrier)
Downstream interleave depth setting	___ (# of taps) ____(increments)
____ DOCSIS Service	
Upstream RF bandwidth allocated	____ MHz (max) ____ MHz (min)
Upstream modulation type	____ QPSK ____ 16QAM
Upstream input level expected at CMTS	____ dBmV
FEC enabled? If yes, FEC level parameters (T and K)	____ yes ____ no ____ T ____ K
Upstream measured C/N	____ dB
Downstream RF bandwidth allocated	____ MHz (max) ____ MHz (min)
Downstream modulation type	____ 64QAM ____256QAM
Downstream output signal level (relative to analog video)	____ dB
Downstream measured C/N	____ dB (DOSCIS carrier) ____ dB (Analog video carrier)
Downstream interleave depth setting	___ (# of taps) ____(increments)

Table 36: Upstream CMTS Parameter Characterization

Upstream Parameters	Port 0	Port 1	Port 2	Port 3
DOCSIS Module #___				
Node combining ratio per port	____ : 1	____ : 1	____ : 1	____ : 1
Expected interfaces per port				
Expected port input level	____ dBmV	____ dBmV	____ dBmV	____ dBmV
Modulation type (where applicable)	_ QPSK _ 16QAM (CH0) _ QPSK _ 16QAM (CH1) _ QPSK _ 16QAM (CH2) _ QPSK _ 16QAM (CH3) _ QPSK _ 16QAM (CH4) _ QPSK _ 16QAM (CH5) _ QPSK _ 16QAM (CH6) _ QPSK _ 16QAM (CH7) _ QPSK _ 16QAM (CH8) _ QPSK _ 16QAM (CH9) _ QPSK _ 16QAM (CH10) _ QPSK _ 16QAM (CH11) _ QPSK _ 16QAM (CH12) _ QPSK _ 16QAM (CH13) _ QPSK _ 16QAM (CH14) _ QPSK _ 16QAM (CH15)	_ QPSK _ 16QAM (CH0) _ QPSK _ 16QAM (CH1) _ QPSK _ 16QAM (CH2) _ QPSK _ 16QAM (CH3) _ QPSK _ 16QAM (CH4) _ QPSK _ 16QAM (CH5) _ QPSK _ 16QAM (CH6) _ QPSK _ 16QAM (CH7) _ QPSK _ 16QAM (CH8) _ QPSK _ 16QAM (CH9) _ QPSK _ 16QAM (CH10) _ QPSK _ 16QAM (CH11) _ QPSK _ 16QAM (CH12) _ QPSK _ 16QAM (CH13) _ QPSK _ 16QAM (CH14) _ QPSK _ 16QAM (CH15)	_ QPSK _ 16QAM (CH0) _ QPSK _ 16QAM (CH1) _ QPSK _ 16QAM (CH2) _ QPSK _ 16QAM (CH3) _ QPSK _ 16QAM (CH4) _ QPSK _ 16QAM (CH5) _ QPSK _ 16QAM (CH6) _ QPSK _ 16QAM (CH7) _ QPSK _ 16QAM (CH8) _ QPSK _ 16QAM (CH9) _ QPSK _ 16QAM (CH10) _ QPSK _ 16QAM (CH11) _ QPSK _ 16QAM (CH12) _ QPSK _ 16QAM (CH13) _ QPSK _ 16QAM (CH14) _ QPSK _ 16QAM (CH15)	_ QPSK _ 16QAM (CH0) _ QPSK _ 16QAM (CH1) _ QPSK _ 16QAM (CH2) _ QPSK _ 16QAM (CH3) _ QPSK _ 16QAM (CH4) _ QPSK _ 16QAM (CH5) _ QPSK _ 16QAM (CH6) _ QPSK _ 16QAM (CH7) _ QPSK _ 16QAM (CH8) _ QPSK _ 16QAM (CH9) _ QPSK _ 16QAM (CH10) _ QPSK _ 16QAM (CH11) _ QPSK _ 16QAM (CH12) _ QPSK _ 16QAM (CH13) _ QPSK _ 16QAM (CH14) _ QPSK _ 16QAM (CH15)
Channel width (where applicable) Circle the applicable unit.	____ kHz/MHz (CH 0) ____ kHz/MHz (CH 1) ____ kHz/MHz (CH 2) ____ kHz/MHz (CH 3) ____ kHz/MHz (CH 4) ____ kHz/MHz (CH 5) ____ kHz/MHz (CH 6) ____ kHz/MHz (CH 7) ____ kHz/MHz (CH 8) ____ kHz/MHz (CH 9) ____ kHz/MHz (CH 10) ____ kHz/MHz (CH 11) ____ kHz/MHz (CH 12) ____ kHz/MHz (CH 13) ____ kHz/MHz (CH 14) ____ kHz/MHz (CH 15)	____ kHz/MHz (CH 0) ____ kHz/MHz (CH 1) ____ kHz/MHz (CH 2) ____ kHz/MHz (CH 3) ____ kHz/MHz (CH 4) ____ kHz/MHz (CH 5) ____ kHz/MHz (CH 6) ____ kHz/MHz (CH 7) ____ kHz/MHz (CH 8) ____ kHz/MHz (CH 9) ____ kHz/MHz (CH 10) ____ kHz/MHz (CH 11) ____ kHz/MHz (CH 12) ____ kHz/MHz (CH 13) ____ kHz/MHz (CH 14) ____ kHz/MHz (CH 15)	____ kHz/MHz (CH 0) ____ kHz/MHz (CH 1) ____ kHz/MHz (CH 2) ____ kHz/MHz (CH 3) ____ kHz/MHz (CH 4) ____ kHz/MHz (CH 5) ____ kHz/MHz (CH 6) ____ kHz/MHz (CH 7) ____ kHz/MHz (CH 8) ____ kHz/MHz (CH 9) ____ kHz/MHz (CH 10) ____ kHz/MHz (CH 11) ____ kHz/MHz (CH 12) ____ kHz/MHz (CH 13) ____ kHz/MHz (CH 14) ____ kHz/MHz (CH 15)	____ kHz/MHz (CH 0) ____ kHz/MHz (CH 1) ____ kHz/MHz (CH 2) ____ kHz/MHz (CH 3) ____ kHz/MHz (CH 4) ____ kHz/MHz (CH 5) ____ kHz/MHz (CH 6) ____ kHz/MHz (CH 7) ____ kHz/MHz (CH 8) ____ kHz/MHz (CH 9) ____ kHz/MHz (CH 10) ____ kHz/MHz (CH 11) ____ kHz/MHz (CH 12) ____ kHz/MHz (CH 13) ____ kHz/MHz (CH 14) ____ kHz/MHz (CH 15)

Upstream Parameters	**Port 0**	**Port 1**	**Port 2**	**Port 3**
FEC enabled? If yes, FEC level parameters	_____ yes _____ no ____ T ____ K (CH 0) ____ T ____ K (CH 1) ____ T ____ K (CH 2) ____ T ____ K (CH 3) ____ T ____ K (CH 4) ____ T ____ K (CH 5) ____ T ____ K (CH 6) ____ T ____ K (CH 7) ____ T ____ K (CH 8) ____ T ____ K (CH 9) ____ T ____ K (CH 10) ____ T ____ K (CH 11) ____ T ____ K (CH 12) ____ T ____ K (CH 13) ____ T ____ K (CH 14) ____ T ____ K (CH 15)	_____ yes _____ no ____ T ____ K (CH 0) ____ T ____ K (CH 1) ____ T ____ K (CH 2) ____ T ____ K (CH 3) ____ T ____ K (CH 4) ____ T ____ K (CH 5) ____ T ____ K (CH 6) ____ T ____ K (CH 7) ____ T ____ K (CH 8) ____ T ____ K (CH 9) ____ T ____ K (CH 10) ____ T ____ K (CH 11) ____ T ____ K (CH 12) ____ T ____ K (CH 13) ____ T ____ K (CH 14) ____ T ____ K (CH 15)	_____ yes _____ no ____ T ____ K (CH 0) ____ T ____ K (CH 1) ____ T ____ K (CH 2) ____ T ____ K (CH 3) ____ T ____ K (CH 4) ____ T ____ K (CH 5) ____ T ____ K (CH 6) ____ T ____ K (CH 7) ____ T ____ K (CH 8) ____ T ____ K (CH 9) ____ T ____ K (CH 10) ____ T ____ K (CH 11) ____ T ____ K (CH 12) ____ T ____ K (CH 13) ____ T ____ K (CH 14) ____ T ____ K (CH 15)	_____ yes _____ no ____ T ____ K (CH 0) ____ T ____ K (CH 1) ____ T ____ K (CH 2) ____ T ____ K (CH 3) ____ T ____ K (CH 4) ____ T ____ K (CH 5) ____ T ____ K (CH 6) ____ T ____ K (CH 7) ____ T ____ K (CH 8) ____ T ____ K (CH 9) ____ T ____ K (CH 10) ____ T ____ K (CH 11) ____ T ____ K (CH 12) ____ T ____ K (CH 13) ____ T ____ K (CH 14) ____ T ____ K (CH 15)
Interface frequency (where applicable)	____ MHz (CH 0) ____ MHz (CH 1) ____ MHz (CH 2) ____ MHz (CH 3) ____ MHz (CH 4) ____ MHz (CH 5) ____ MHz (CH 6) ____ MHz (CH 7) ____ MHz (CH 8) ____ MHz (CH 9) ____ MHz (CH 10) ____ MHz (CH 11) ____ MHz (CH 12) ____ MHz (CH 13) ____ MHz (CH 14) ____ MHz (CH 15)	____ MHz (CH 0) ____ MHz (CH 1) ____ MHz (CH 2) ____ MHz (CH 3) ____ MHz (CH 4) ____ MHz (CH 5) ____ MHz (CH 6) ____ MHz (CH 7) ____ MHz (CH 8) ____ MHz (CH 9) ____ MHz (CH 10) ____ MHz (CH 11) ____ MHz (CH 12) ____ MHz (CH 13) ____ MHz (CH 14) ____ MHz (CH 15)	____ MHz (CH 0) ____ MHz (CH 1) ____ MHz (CH 2) ____ MHz (CH 3) ____ MHz (CH 4) ____ MHz (CH 5) ____ MHz (CH 6) ____ MHz (CH 7) ____ MHz (CH 8) ____ MHz (CH 9) ____ MHz (CH 10) ____ MHz (CH 11) ____ MHz (CH 12) ____ MHz (CH 13) ____ MHz (CH 14) ____ MHz (CH 15)	____ MHz (CH 0) ____ MHz (CH 1) ____ MHz (CH 2) ____ MHz (CH 3) ____ MHz (CH 4) ____ MHz (CH 5) ____ MHz (CH 6) ____ MHz (CH 7) ____ MHz (CH 8) ____ MHz (CH 9) ____ MHz (CH 10) ____ MHz (CH 11) ____ MHz (CH 12) ____ MHz (CH 13) ____ MHz (CH 14) ____ MHz (CH 15)
Required interface input level (where applicable)	____ dBmV (CH 0) ____ dBmV (CH 1) ____ dBmV (CH 2) ____ dBmV (CH 3) ____ dBmV (CH 4) ____ dBmV (CH 5) ____ dBmV (CH 6) ____ dBmV (CH 7) ____ dBmV (CH 8) ____ dBmV (CH 9) ____ dBmV (CH 10) ____ dBmV (CH 11) ____ dBmV (CH 12) ____ dBmV (CH 13) ____ dBmV (CH 14) ____ dBmV (CH 15)	____ dBmV (CH 0) ____ dBmV (CH 1) ____ dBmV (CH 2) ____ dBmV (CH 3) ____ dBmV (CH 4) ____ dBmV (CH 5) ____ dBmV (CH 6) ____ dBmV (CH 7) ____ dBmV (CH 8) ____ dBmV (CH 9) ____ dBmV (CH 10) ____ dBmV (CH 11) ____ dBmV (CH 12) ____ dBmV (CH 13) ____ dBmV (CH 14) ____ dBmV (CH 15)	____ dBmV (CH 0) ____ dBmV (CH 1) ____ dBmV (CH 2) ____ dBmV (CH 3) ____ dBmV (CH 4) ____ dBmV (CH 5) ____ dBmV (CH 6) ____ dBmV (CH 7) ____ dBmV (CH 8) ____ dBmV (CH 9) ____ dBmV (CH 10) ____ dBmV (CH 11) ____ dBmV (CH 12) ____ dBmV (CH 13) ____ dBmV (CH 14) ____ dBmV (CH 15)	____ dBmV (CH 0) ____ dBmV (CH 1) ____ dBmV (CH 2) ____ dBmV (CH 3) ____ dBmV (CH 4) ____ dBmV (CH 5) ____ dBmV (CH 6) ____ dBmV (CH 7) ____ dBmV (CH 8) ____ dBmV (CH 9) ____ dBmV (CH 10) ____ dBmV (CH 11) ____ dBmV (CH 12) ____ dBmV (CH 13) ____ dBmV (CH 14) ____ dBmV (CH 15)

Table 37: Downstream CMTS Parameter Characterization

Downstream Parameters	Port 0	Port 1	Port 2	Port 3
DOCSIS Module #___				
Node combining ratio per port	____ : 1	____ : 1	____ : 1	____ : 1
Interface frequency allocated	____ MHz	____ MHz	____ MHz	____ MHz
Modulation type	_ 64QAM _256QAM	_ 64QAM _256QAM	_ 64QAM _256QAM	_ 64QAM _256QAM
Output signal level (relative to analog video)	____ dB	____ dB	____ dB	____ dB
Required interface output level	____ dBmV	____ dBmV	____ dBmV	____ dBmV
Interleave depth setting	___ [I] (# of taps) ___ [J] (increments)	___ [I] (# of taps) ___ [J] (increments)	___ [I] (# of taps) ___ [J] (increments)	___ [I] (# of taps) ___ [J] (increments)

Verification of Shipping Cartons

Prior to beginning the installation of the G10 CMTS, you should verify that the contents of the shipping cartons are identical to the contents listed on the packing lists. In addition, you should carefully inspect the shipped contents to ensure that they are not damaged in any manner. If any contents are missing or damaged, report this to customer support.

To verify the contents of the shipping cartons match the packing list, use the following procedure:

1. Carefully open the shipping cartons. Pay attention to any instructions printed on each shipping carton.

2. Remove all the contents of the shipping cartons. When lifting heavy contents, be sure to follow the safety precautions listed in "Safety Precautions" on page 68.

3. Verify that the contents of the shipping cartons are identical to the contents listed on the packing lists.

4. Verify that the correct number of power supplies are installed in the G10 CMTS chassis.

5. Open all accessory kits that are included in the shipment. Verify that the contents are identical to the contents listed on the accessory kit packing lists.

6. Install the power supply faceplate included in the shipment by aligning its four ball studs with the four power supply faceplate clips and pressing the faceplate towards the chassis until it snaps into place. If you will install additional power supplies, this step can be deferred.

> **Caution**
>
> You must install the power supply faceplate prior to powering on the G10 CMTS to ensure that proper air ventilation occurs throughout the chassis.

7. Install the air intake faceplate included in the shipment by aligning its four ball studs with the four air intake faceplate clips and pressing the faceplate towards the chassis until it snaps into place.

G10 CMTS Installation Checklist

Table 38 summarizes all the steps outlined in this document that are required to successfully install the G10 CMTS in the headend. We recommend that copies of this table be made and used to keep track of the installation status of each G10 CMTS.

Table 38: G10 CMTS Installation Checklist

Step	Page Number	Completion Status
Preparation for Installation		
Complete all checklists in "Prepare the Site"	page 67	
Completely review the *G10 CMTS Hardware Guide*, including the safety precautions	—	
Verify the contents of the shipping cartons	page 89	
Verify the number of pre-installed modules and power supplies in the chassis is correct		
Verify the contents of all accessory kits		
Install the power supply faceplate and the air intake faceplate		
Ground and Rack Mount the Chassis		
Crimp the supplied two-ring lug connector to the earth ground strap	page 94	
Attach the earth ground strap to the chassis		
Ensure proper ventilation clearance surrounding the G10 CMTS	page 94	
Install an equipment shelf in the rack		
If applicable, install the rack mounting brackets		
Slide the chassis onto the shelf and mount it to the rack		
Attach the earth ground strap to earth ground		
Install Power Supplies		
Remove the power supply faceplate	page 101	
Determine the bay in which to install the power supply		
Remove the power supply filler panel		
Release the ejector, align to the card guides, insert the power supply, and close the ejector		
Tighten the self-contained screws		
Replace the power supply faceplate		
Install a DOCSIS Module and an HFC Connector Module or SIM		
Remove the air management module where the DOCSIS Module will be inserted	page 103	
Release the ejectors, align to the card guides, insert the DOCSIS Module, and close the ejectors		
Tighten the self-contained screws		
Remove the air management panel where the HFC Connector Module or SIM will be inserted		
Release the ejectors, align to the card guides, insert the HFC Connector Module or SIM, and close the ejectors		
Tighten the self-contained screws		

Step	Page Number	Completion Status
Install a Chassis Control Module and a Hard Disk Module		
Remove the air management module where the Chassis Control Module will be inserted	page 108	
Release the ejectors, align to the card guides, insert the Chassis Control Module, and close the ejectors		
Tighten the self-contained screws		
Remove the air management panel where the Hard Disk Module will be inserted		
Release the ejectors, align to the card guides, insert the Hard Disk Module, and close the ejectors		
Tighten the self-contained screws		
Install a NIC Module and a NIC Access Module		
Remove the air management module where the NIC Module will be inserted	page 108	
Release the ejectors, align to the card guides, insert the NIC Module, and close the ejectors		
Tighten the self-contained screws		
Remove the air management panel where the NIC Access Module will be inserted		
Release the ejectors, align to the card guides, insert the NIC Access Module, and close the ejectors		
Tighten the self-contained screws		
Cable an HFC Connector Module or SIM		
Determine how the cable plant nodes will be connected to the downstream and upstream ports of the module	page 109	
Connect each of the four downstream ports to its respective node		
Connect each of the four upstream ports to its respective node		
Dress all cables appropriately		
Cable a Chassis Control Module		
Thread the Ethernet cable through the cable channel from the rear of the chassis	page 113	
Connect the RJ-45 connector of the Ethernet cable to the Eth0 port on the Chassis Control Module		
Connect the other end of the Ethernet cable to its respective network equipment in the headend		
Cable a NIC Module and a NIC Access Module (if applicable)		
Thread the network cables through the cable channel from the rear of the chassis	page 113	
Connect each of the two Gigabit Ethernet network cables to the ports on the NIC Module		
Connect the other ends of the network cables to their respective network equipment in the headend		
Connect the RJ-21 end of the NIC Access Module cable into the NIC Access Module and tighten the cable retainer screws		
Connect eight RJ-45 connectors of the NIC Access Module cable to a maximum of four HFC Connector Module		
Dress all cables appropriately		
Attach a PC to the Chassis Control Module		
Connect the serial cable to the COM port on the Chassis Control Module	page 119	
Connect the other end of the serial cable to the serial port on the PC		

Step	Page Number	Completion Status
Connect to Power Sources		
Ensure that each power distribution rocker switch is OFF (AC only)	page 119	
Plug each power cord into the power receptacles (AC) or terminal blocks (DC)		
Close the retainer clips around the power cords (AC) or secure the DC ring lugs to the terminal blocks (DC)		
Plug the other ends of the power cords to their respective, independent power sources		
Power On the G10 CMTS		
Ensure that the power sources are on	page 123	
Turn on the power switches on the power transition modules (AC only)		
Check all power supply LEDs (power supply faceplate must be removed, then replaced)		
Check front and rear fan tray LEDs		
Check all DOCSIS Module LEDs		
Check all Chassis Control Module LEDs		
Check all NIC Module LEDs		
Power On and Configure the PC		
Power on the PC, launch the asynchronous terminal emulation application, and establish a direct serial connection with the Chassis Control Module	page 127	
Check for correct boot banner and system prompt on PC		
Log into the G10 CMTS		
Perform Initial Software Configuration		
Configure the name of the CMTS	page 128	
Configure the CMTS's domain name		
Configure the IP address of the Fast Ethernet management port		
Configure the IP address of a backup router		
Configure the IP address of a DNS server		
Set the root authentication password		

Chapter 5
Install the CMTS

This chapter describes the complete installation procedure for the G10 CMTS. It is assumed that you have followed all safety precautions and procedures described in “Prepare the Site” on page 67 prior to performing the procedures presented in this chapter. We recommend that the entire installation process in this chapter be read prior to performing the actual G10 CMTS installation.

> **Caution**
>
> Before installing a power supply or any module into the G10 CMTS, attach one end of an ESD ground strap to your wrist and attach the other end to the ESD strap jack on the front of the chassis (see Figure 5 on page 12).

This chapter discusses the following topics:

- Connect to Power Sources on page 119

Ground the Chassis

Prior to rack mounting the G10 CMTS, you should install an earth ground strap on the chassis, particularly if the sides of the chassis will be inaccessible after it is rack mounted. Figure 6 on page 13 shows the location of the chassis ground nuts on the chassis. The G10 CMTS accessory kit contains a two-ring lug connector that you must crimp to the ground strap. Using two of the supplied #12 screws and washers (a washer is installed between each bolt and the lug connector), attach the ground strap to the chassis using 35 in-lb of torque on each screw. The other end of the ground strap will be attached to earth ground after the chassis is rack mounted.

Warning

Never power on the G10 CMTS without first grounding the chassis.

Rack Mounting

This section describes the process for rack mounting the G10 CMTS into an EIA standard 19-inch rack. The mounting brackets are compatible with either of the following racks:

- Standard 1-3/4” EIA wide
  1-1/4”, 1/2”, 1-1/4”
  12-24 tapped

- Standard 2” EIA wide
  1”, 1”
  12-24 tapped

The G10 CMTS is shipped from the factory with mounting brackets attached to the front of the chassis for front-rack mounting. If the chassis is to be mid-rack mounted, you must remove and reinstall the mounting brackets to the center of the chassis.

The following procedure assumes that all the contents of the shipping cartons, including the G10 CMTS chassis, have been removed.

Note

You must rack mount the G10 CMTS chassis prior to the installation of any additional power supplies or modules.

> **Caution:** In general, when more than one piece of equipment is mounted into a rack, you should install the heaviest piece of equipment at the bottom of the rack. Each successive piece you install should be lighter than the piece immediately below it. For planning purposes, a minimally-populated G10 CMTS weighs approximately 80 lb (36 kg), and a fully-populated G10 CMTS weighs approximately 140 lb (64 kg).

To rack mount the chassis, follow this procedure:

1. Prior to rack mounting, ensure that proper clearance is maintained between the G10 CMTS chassis and its surroundings to allow adequate air ventilation to flow into the air intakes and out of the air exhaust:

   - A minimum of 3 feet (0.91 m) between the front of the chassis and any other object.
   - A minimum of 2 feet (0.61 m) between the rear of the chassis and any other object.
   - A minimum of 3 inches between each side of the chassis and any other object.

   Figure 25 on page 96 illustrates the air flow through the chassis.

   If there is no other equipment installed in the rack, you should install the G10 CMTS as low as possible into the rack.

   > **Caution:** You must install the power supply faceplate prior to powering on the G10 CMTS to ensure that proper air flow occurs throughout the chassis.

   > **Note:** The G10 CMTS does not require any clearance between the bottom of the chassis and the floor. Similarly, there are no clearance requirements between the top of the chassis and the bottom of another G10 CMTS stacked above it on the same rack (see Figure 29 on page 100).

2. We recommend that you install an equipment shelf into the rack that can support the maximum weight (140 lb, or 64 kg) and dimensions of the chassis. The chassis dimensions, when viewed from the bottom, are provided in Figure 26 on page 97.

3. If the chassis will be front-rack mounted, jump ahead to step 5. If the chassis will be mid-rack mounted, proceed to step 4.

4. Remove the seven screws fastening the mounting brackets to the front of the chassis, align the brackets with the corresponding hole patterns in the center of the chassis, and insert the seven screws into the chassis. Apply 20 in-lb of torque to each of the seven screws.

Figure 25: Air Flow Through Chassis

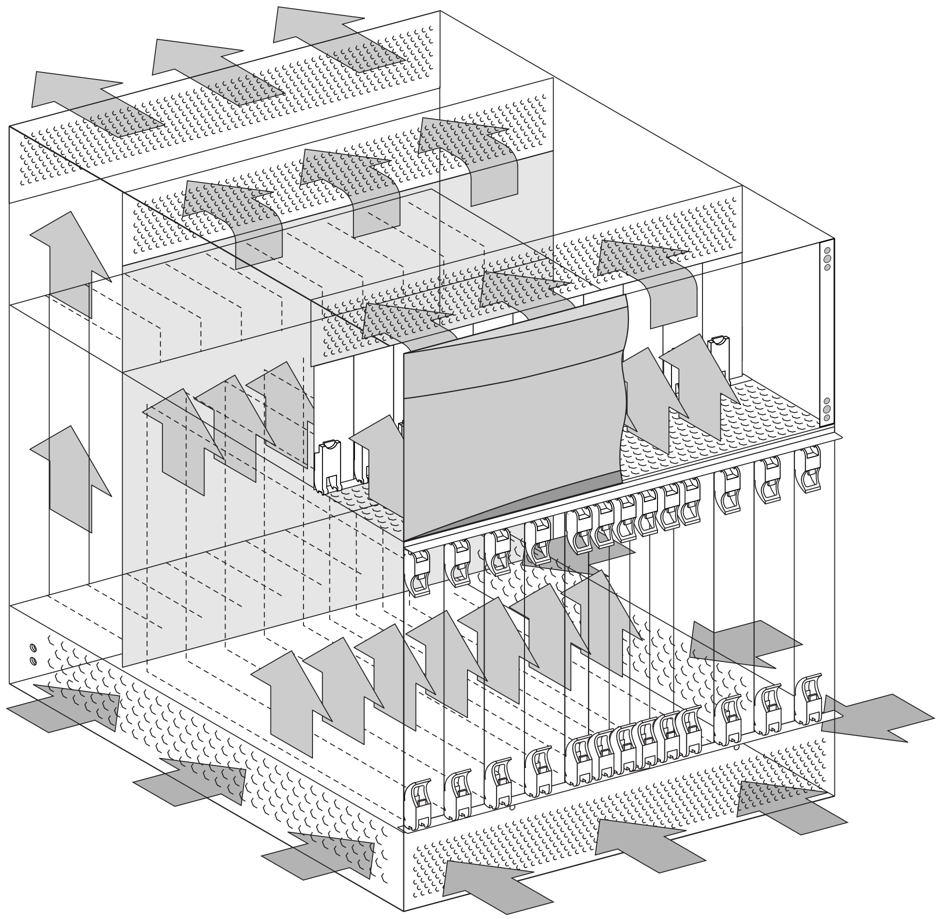
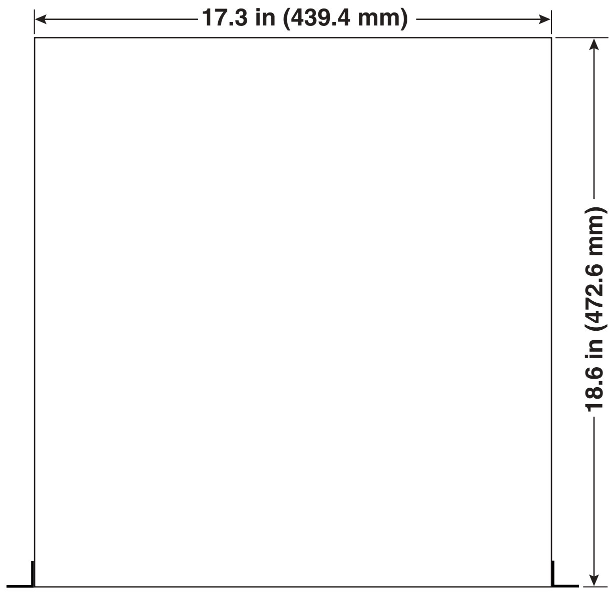


Figure 26: Bottom of Chassis



5. When lifting the chassis, we recommend that you follow the safety precautions listed in the "Safety Precautions" on page 68. Using a lift (or at least three installers—one on the left, one on the right, and one in the front of the chassis), slowly lift and slide the G10 CMTS onto the equipment shelf. Figure 27 on page 98 illustrates the proper manner in which to manually lift the chassis such that the risk of injury is minimized.

> **Caution**
>
> Do not use the handles on the rear fan tray to assist with lifting the G10 CMTS. These handles are solely for the purpose of removing the rear fan tray.

6. Continue sliding the chassis all the way into the rack until the flanges of the mounting brackets are flush with the mounting rails of the rack and the mounting holes in the mounting brackets are aligned with the corresponding holes in the mounting rails.

7. Using the #12 screws supplied in the accessory kit (up to six for each mounting bracket), fasten the chassis to the rack by applying 30 in-lb of torque to each of the screws (see Figure 28 on page 99). Do not completely tighten any screw to its torque specification until all 12 screws are inserted.

8. Attach the ground strap to earth ground. Figure 29 on page 100 illustrates a fully populated rack with three G10 CMTS chassis.

Now you can install additional power supplies and modules.

Figure 27: Lifting the Chassis

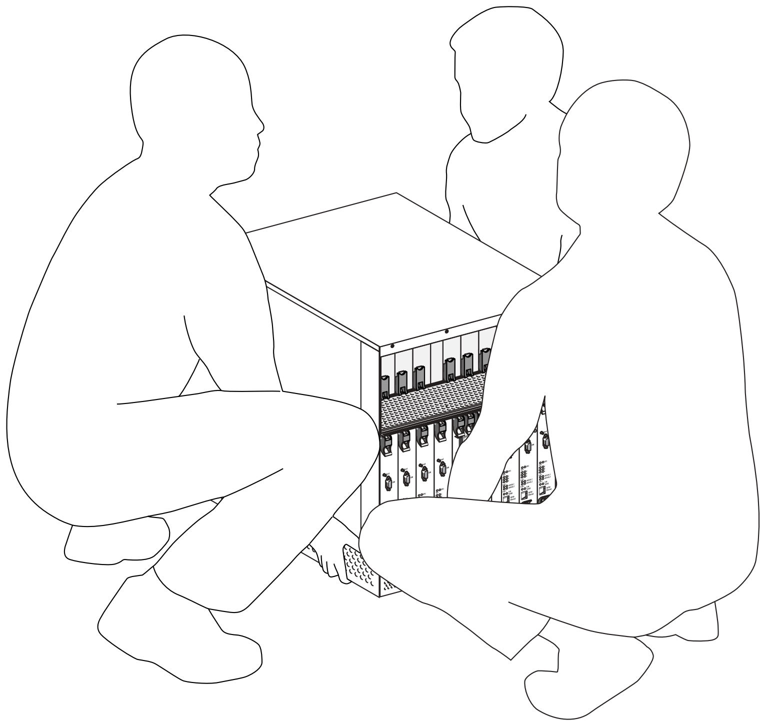


Figure 28: Rack-Mounted Chassis

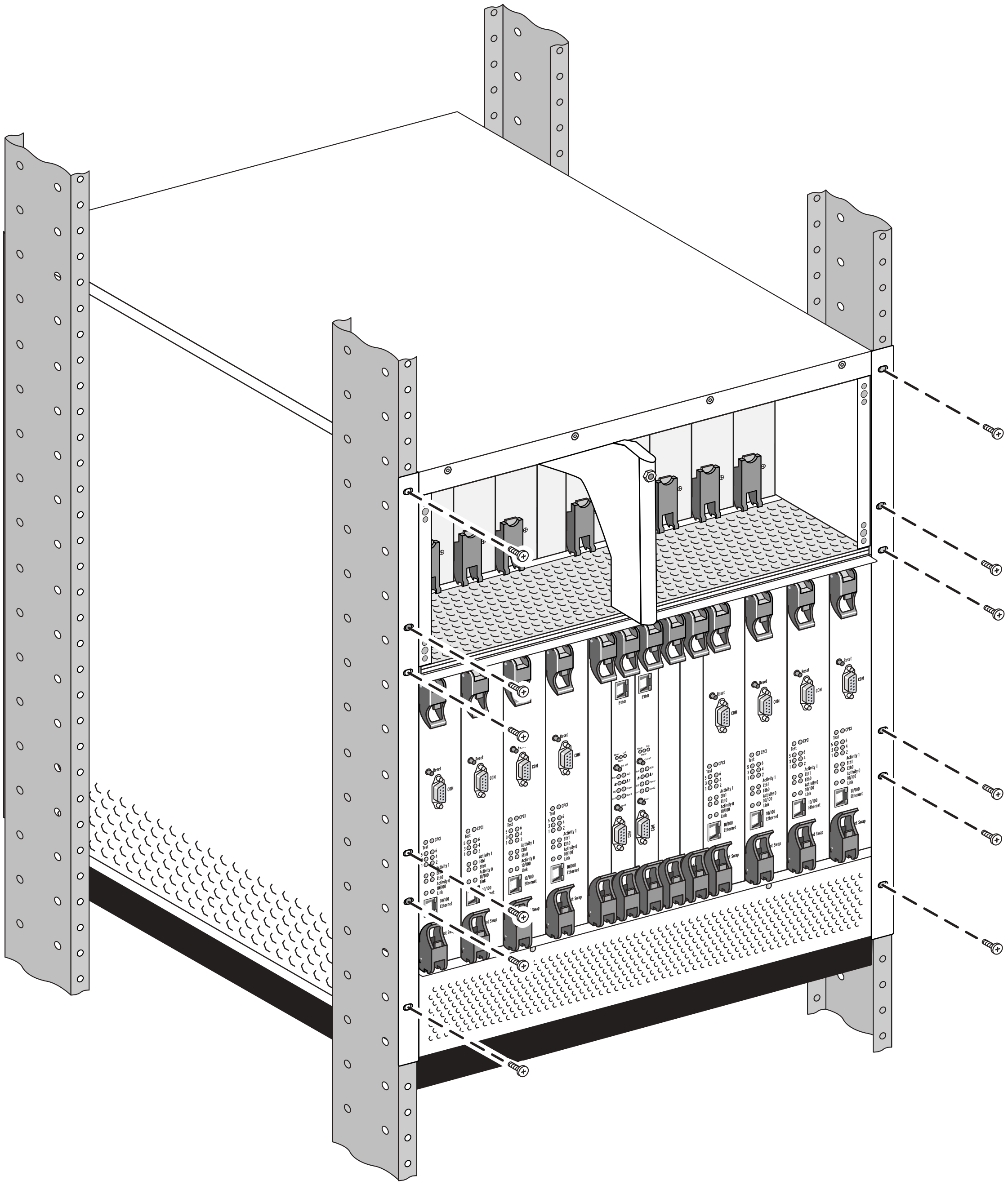
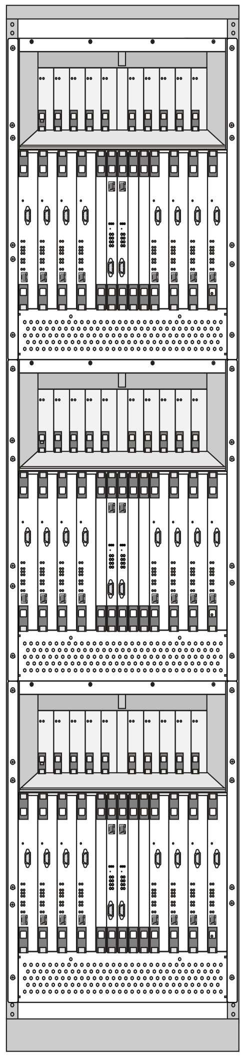


Figure 29: Rack Fully Populated with Three G10 CMTS Chassis



Install Power Supplies

If you order an AC version of the CMTS without power redundancy, the CMTS ships with five AC power supplies installed in domain A. If you order the CMTS with power redundancy, the CMTS ships with 10 AC power supplies installed. DC versions of the CMTS are always shipped with 10 DC power supplies installed.

To install an additional power supply, follow this procedure:

1. Remove the power supply faceplate by pulling the flanges on each side of the faceplate away from the chassis until the faceplate ball studs are removed from the power supply faceplate clips.

2. Remove the power supply filler panel covering the selected bay by loosening the two self-contained screws.

3. If the power supply's ejector is locked in the vertical position, press down on the ejector release while simultaneously pulling the ejector away from the power supply. The ejector should rest at approximately 45° from the faceplate.

> **Caution**
> The power supplies and the chassis are mechanically keyed to ensure that the same type of supplies and chassis (AC or DC) are used together. Do not attempt to remove or reconfigure the keys.

4. Each power supply bay has an upper and lower card guide. Align the printed circuit board of the power supply with the bay card guides and slowly slide the power supply into the bay until it comes to a stop (action #1 in Figure 30 on page 102). The inside tabs (the tabs closest to midplane) of the ejector should be resting over the power supply ejector rail.

5. Firmly lift the ejector to the vertical position until the ejector release clicks into position (action #2 in Figure 30). Check that the inside tabs of the ejector extend into the power supply ejector rail. The power supply should be flush with any other installed power supplies.

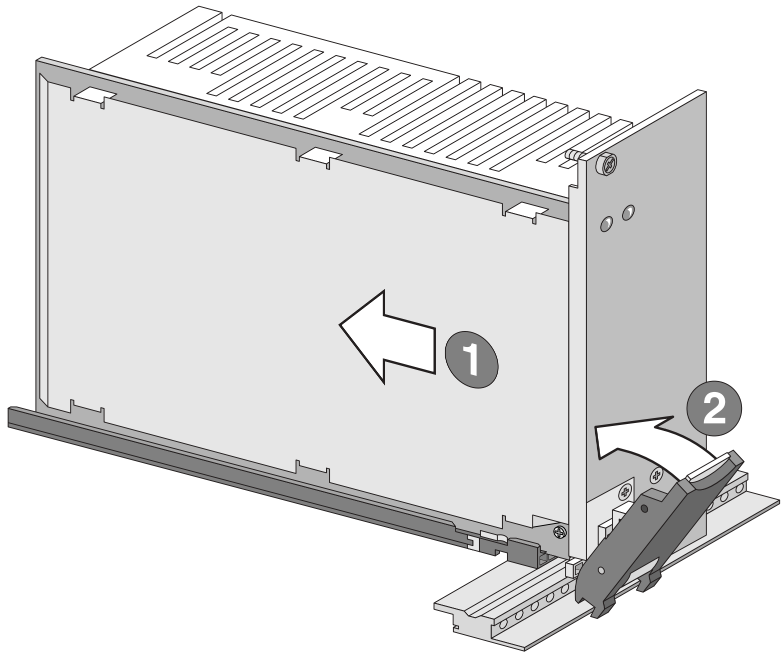
6. Tighten the upper and lower retainer screws by applying 3 in-lb of torque to each screw.

7. Replace the power supply faceplate by aligning its four ball studs with the four power supply faceplate clips and pressing the faceplate towards the chassis until it snaps into place.

> **Caution**
> You must replace the power supply faceplate and power supply filler panels prior to powering on the G10 CMTS to ensure that proper air ventilation occurs throughout the chassis, and to reduce EMI emissions.

See "Remove Power Supplies" on page 160 for power supply removal instructions.

Figure 30: Power Supply Installation



Install a DOCSIS Module

The G10 CMTS chassis accommodates a total of eight DOCSIS Modules. The chassis is not shipped from the factory with any DOCSIS Modules installed into any card cage slots. All DOCSIS Modules that you order are packaged separately and must be installed at the headend after the G10 CMTS has been rack mounted. The card cage is shipped from the factory with seven air management modules installed in front slots that do not contain DOCSIS Modules, and seven air management panels into rear slots that do not contain HFC Connector Modules or SIMs. These air management modules and panels act as baffles that prevent air from flowing upward through empty space or out of the chassis, and redirect the air flow through slots that contain active modules. A single card cage slot (front and back) is intentionally left empty when shipped from the factory because at least one DOCSIS Modules and one HFC Connector Module or SIM must be installed in the system.

DOCSIS Modules are installed in the front of the G10 CMTS chassis in card cage slots 1 through 4 (for domain A) and slots 10 through 13 (for domain B). HFC Connector Modules and SIMs are installed in the rear of the G10 CMTS chassis in card cage slots 1 through 4 (for domain A) and slots 10 through 13 (for domain B). See Figure 10 on page 25 for an illustration of the chassis domains.

To assist with the installation, the top of the air intake faceplate, the bottom of the power supply faceplate, and the top of the rear fan tray are labeled with the slot numbers.

To install a DOCSIS Module, follow this procedure:

1. If applicable, remove the air management module from the slot. Loosen the two retainer screws, then press upward and downward on the ejector releases (action #1 in Figure 31 on page 104). Simultaneously pull the ejectors away from the module faceplate (action #2 in Figure 31), and slowly slide the module out of its slot until it is fully removed from the system (action #3 in Figure 31).

2. Remove the module from its anti-static bag, being careful to avoid directly touching any component on the module. We recommend that you handle the module by by its card edges or ejectors.

> **Caution**
>
> If any G10 CMTS module has been removed from its anti-static bag and must be temporarily put aside prior to its installation, you should replace the module into the anti-static bag or on top of an anti-static mat that is properly grounded.

3. If the upper or lower ejector of the module is locked in the vertical position, press upward or downward on the ejector release while simultaneously pulling the ejector away from the module faceplate. Each ejector should rest at approximately 45° away from its locked position.

4. Each card cage slot in the front of the chassis has an upper and lower card guide. Align the printed circuit board of the module with the card guides and slowly slide the module into the slot until it comes to a stop (action #1 in Figure 32 on page 105). The inside tabs (tabs closest to midplane) of the upper and lower ejectors should be resting directly under and over the module ejector rail.

5. Simultaneously push the ejectors toward the module faceplate until they are vertical and each ejector clicks into position. The module faceplate should be flush with the faceplate of any other adjacent module.

6. Tighten the two retainer screws by applying 3 in-lb of torque to each screw.

Figure 31: Air Management Module Removal

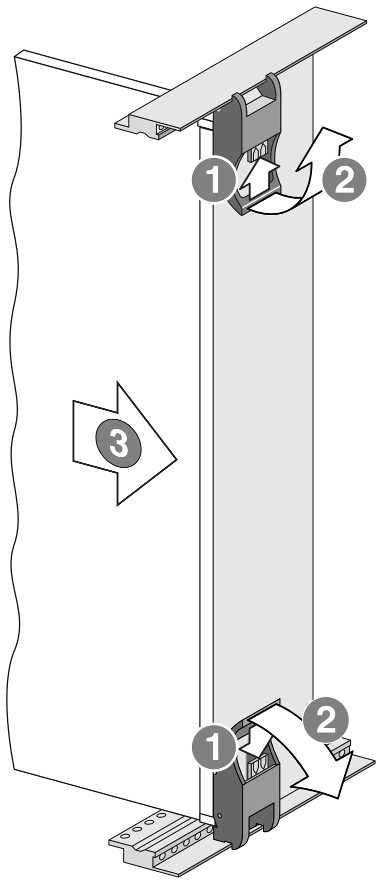
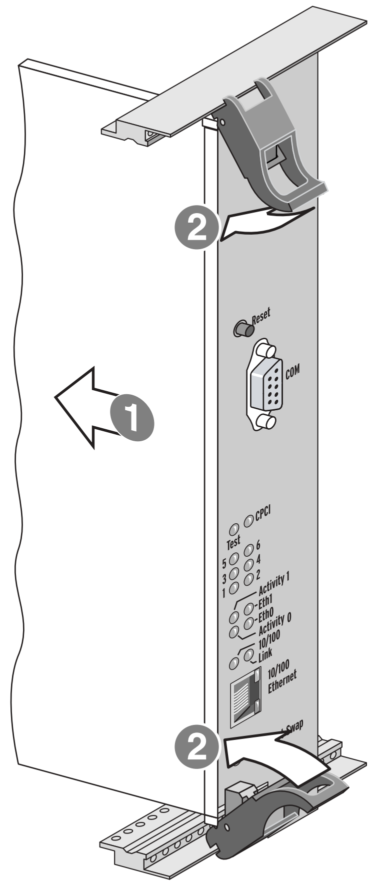


Figure 32: DOCSIS Module Installation



Install an HFC Connector Module or SIM

To install an HFC Connector Module or SIM, follow this procedure:

1. If applicable, remove the air management panel from the slot by loosening the two self-contained screws at the top and bottom of each panel.

2. Remove the module from its anti-static bag, being careful to avoid directly touching any component on the module. We recommend that you handle the module by by its card edges or ejectors.

> **Note**
>
> Unlike a DOCSIS Module, the ejectors on a rear module lock in the horizontal position (90° from the faceplate) when the module is properly installed into its card slot.

3. If the upper or lower ejector of the module is locked in the horizontal position, press upward or downward on the ejector release while simultaneously pulling the ejector away from the module faceplate. Each ejector should rest at approximately 45° away from its locked position.

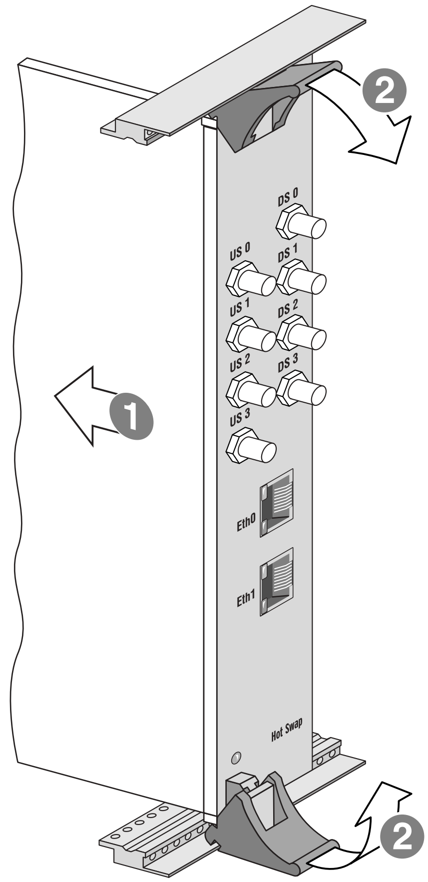
4. Each card cage slot in the rear of the chassis has an upper and lower card guide. Align the printed circuit board of the module with the card guides and slowly slide the module into the slot until it comes to a stop (action #1 in Figure 33 on page 107). The inside tabs (tabs closest to midplane) of the upper and lower ejectors should be resting directly under and over the module ejector rail.

5. Simultaneously push the ejectors toward the module faceplate until they are horizontal and each ejector clicks into position. The module faceplate should be flush with the faceplate of any other adjacent module.

> **Note**
> When you install a rear chassis module, apply more pressure to the upper ejector than to the lower ejector. This ensures the module connectors on the top of the card edge are properly aligned with the midplane connectors. The bottom edge has no connectors, so you do not need to press the rear ejector as firmly.

6. Tighten the two retainer screws by applying 3 in-lb of torque to each screw.

Figure 33: HFC Connector Module Installation



Install a Chassis Control Module

The G10 CMTS chassis accommodates a maximum of two Chassis Control Modules in slots 6 and 7. To install a Chassis Control Module, follow the same procedure described in "Install a DOCSIS Module" on page 103.

Install a Hard Disk Module

You must install a Hard Disk Module opposite each installed Chassis Control Module. To install a Hard Disk Module, follow the same procedure described in "Install an HFC Connector Module or SIM" on page 105.

Install a NIC Module

The G10 CMTS chassis accommodates a maximum of two NIC Modules in slots 5 and 9 for domain A and domain B. NIC Modules are shipped from the factory with two multimode GBIC modules installed. If you are using a different GBIC module interface, you need to replace the multimode GBIC modules that are shipped with the NIC Module. We recommend that you remove and install the GBIC modules while the NIC Module is installed in the chassis.

To install a NIC Module, follow this procedure:

1. Follow the same procedure described in "Install a DOCSIS Module" on page 103. If you will be using a GBIC module interface other than multimode, proceed to step 2. Otherwise, you have completed the installation of the NIC Module.

2. Remove each multimode GBIC module by squeezing the metal clasps at the top and bottom of the GBIC module towards the module and firmly pull out the module until it is removed from its slot.

3. With the label side of the GBIC module facing the right, slide each replacement module into its NIC Module slot until the metal clasps at the top and bottom of the GBIC module click into place.

> **Note**
> The GBIC module can be installed only one way. If you orient the module in its slot incorrectly, it will stop about halfway into the slot. If this occurs, remove the GBIC module, rotate it 180°, and reinstall it.

Install a NIC Access Module

You must install a NIC Access Module opposite each installed NIC Module. To install a NIC Access Module, follow the same procedure described in "Install an HFC Connector Module or SIM" on page 105.

Cable an HFC Connector Module or SIM

This section describes how to connect the four downstream and four upstream F-connector ports of an HFC Connector Module or SIM. This section also describes how to connect the two Fast Ethernet ports on an HFC Connector Module or SIM.

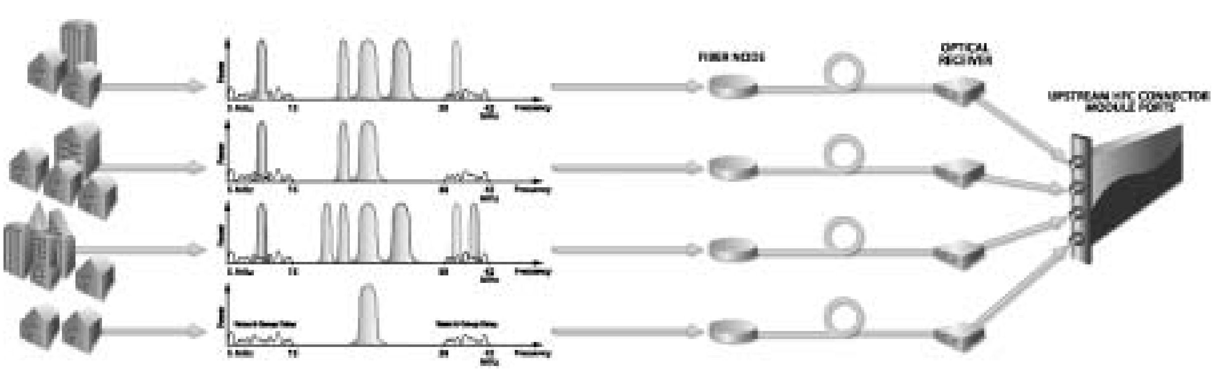
> **Note**
>
> The following ports on the SIM are not used:
>
> - Fast Ethernet ports Eth0-B and Eth1-B
> - Upstream F-connectors US4 through US7
> - Ports DSR-IN and DSR-OUT

Cable the F-connector Ports

> **Caution**
>
> Prior to inserting a coaxial cable into any of the module F-connectors, ensure that the cable meets the requirements provided in “Coaxial Cable Requirements” on page 75.

Each DOCSIS Module, and its corresponding rear HFC Connector Module or SIM, support a total of four downstream interfaces, where one interface is assigned to each physical downstream port. Each DOCSIS Module supports a total of 8 or 16 upstream interfaces (depending on the DOCSIS Module model), which can be allocated to any of the four physical upstream ports (US0 through US3). Figure 34 illustrates an example where the number of interfaces allocated on each port is five, three, seven, and one. You should consider the assignment of a node to a port and the allocation of upstream interfaces to upstream ports prior to connecting the coaxial cables from the cable plant to the HFC Connector Module or SIM.

Figure 34: Example of Allocation of Multiple Interfaces Per Port



One possible deployment scenario for the upstream is to attach one node per upstream port and to turn on one upstream interface per node. If one of the nodes reaches capacity due to high penetration or heavy usage of bandwidth-intensive services, you can provision another interface on that port.

To cable the downstream ports, following this procedure (see Figure 18 on page 51 and Figure 20 on page 54 for port labeling):

1. Select the first node in the cable plant for assignment to the first of four downstream ports.

2. Connect the coaxial cable associated with the first node to the F-connector labeled DS0 on the HFC Connector Module or the SIM.

3. If applicable, select the second, third, and fourth nodes in the cable plant for assignment to the remaining three downstream ports.

4. If applicable, connect the coaxial cables associated with the second, third, and fourth nodes to the F-connectors labeled DS1, DS2, and DS3 on the HFC Connector Module or the SIM.

> **Note**
> When you tighten a coaxial cable onto an F-connector, use a 7/16 inch torque wrench to apply torque according to SCTE standards.

To cable the upstream ports, follow this procedure:

1. Select the first node in the cable plant for assignment to the first of four upstream ports.

2. Connect the coaxial cable associated with the first node to the F-connector labeled US0 on the HFC Connector Module or the SIM.

3. If applicable, select the second, third, and fourth nodes in the cable plant for assignment to the remaining three upstream ports.

4. If applicable, connect the coaxial cables associated with the second, third, and fourth nodes to the F-connectors labeled US1, US2, and US3 on the HFC Connector Module or the SIM.

5. We recommend that you use cable organizers to dress and route all coaxial cables to avoid obstructing the rear connections of the CMTS (see Figure 35 on page 112).

> **Note**
> A node can represent a single node or multiple nodes that are combined.

Note

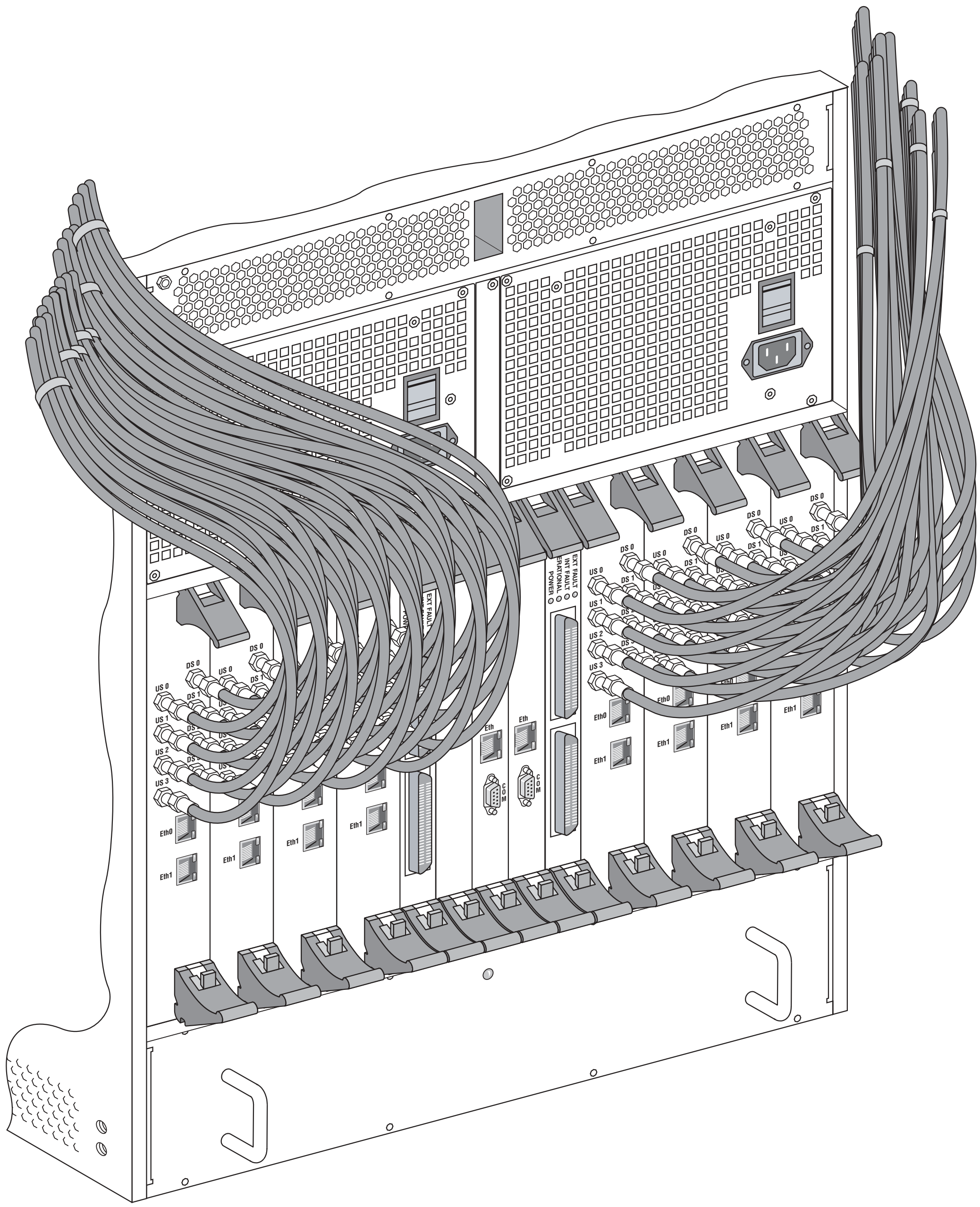
When connecting nodes to the upstream ports of an HFC Connector Module or SIM, do not split a coaxial cable from one node and attach it to more than one upstream port. Doing so prevents you from using the complete features of a DOCSIS Module that are designed for supporting four separate nodes or four groups of nodes that are combined.

If you are not using internal chassis Fast Ethernet wiring (using a version 2 chassis and SIMs), see "Cable a NIC Access Module" on page 115 for a description on how to connect the Fast Ethernet ports of an HFC Connector Module or SIM to the NIC Access Module.

Note

Both Fast Ethernet ports on the HFC Connector Module and the SIM must be connected to the network.

Figure 35: Rear Coaxial Cable Connections



Cable a Chassis Control Module

The Chassis Control Module contains a Fast Ethernet RJ-45 port labeled `Eth0` on its front panel (see Figure 15 on page 39). This port is used for the management interface to the CMTS.

To connect to the Chassis Control Module management port, follow this procedure:

1. Carefully thread the Ethernet cable into the cable channel from the rear of the chassis (see Figure 6 on page 13) until it extends through the opening of the power supply faceplate.

2. Plug the RJ-45 connector of the Ethernet cable into the RJ-45 port of the Chassis Control Module labeled `Eth0`.

3. Attach the other end of the Ethernet cable to its network equipment in the headend.

Cable a NIC Module

The NIC Module contains two full-duplex, Gigabit Ethernet GBIC transceiver ports on its front panel. See “NIC Module” on page 42 for the specifications of the various types of GBIC interfaces provided.

To connect the network cables to the Gigabit Ethernet ports, follow this procedure (see Figure 16 on page 43 for port labeling):

1. Carefully thread each of the two cables into the cable channel from the rear of the chassis (see Figure 6 on page 13) until they extend through the opening of the power supply faceplate.

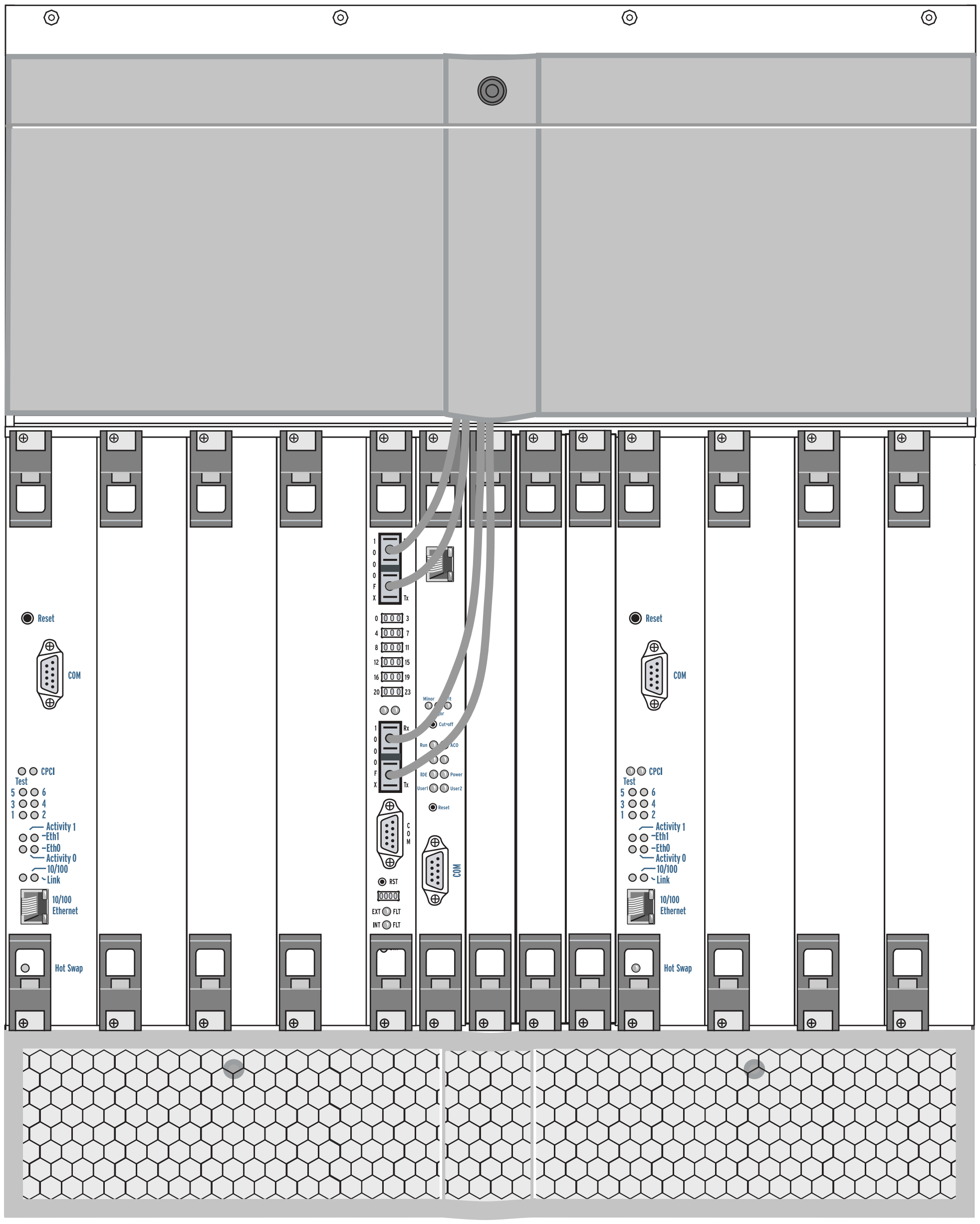
2. Connect the transmit/receive pair of each of these cables to the GBIC ports labeled `0` and `1` on the NIC Module.

3. Attach the other end of each cable to its network equipment in the headend.

> **Caution**
>
> If using optical cables, avoid bending the cables too sharply when threading them through the cable channel.

Figure 36 on page 114 provides the front view of the chassis with the network cables installed into a NIC Module.

Figure 36: NIC Module Cabling – Front View



Cable a NIC Access Module

This section describes how to interconnect up to two NIC Access Modules to multiple HFC Connector Modules or SIMs. The procedure assumes that a NIC Module supports only the DOCSIS Modules installed in the same domain of the chassis. Therefore, if five or more DOCSIS Modules are installed in the system, two NIC Modules are needed to support them. In addition, the procedure assumes that DOCSIS Modules are installed in the following slot order: 1, 2, 3, 4, 10, 11, 12, 13.

The NIC Access Module cables are used to interconnect the Fast Ethernet ports of the HFC Connector Modules or SIMs to the NIC Access Module.

Note

If you are using internal chassis Fast Ethernet wiring (using a version 2 chassis and SIMs), do not attach any cables to the NIC Access Module.

You can use four of the RJ-45 connectors on the NIC Access Module cable plugged into connector 2 on the NIC Access Module as Fast Ethernet interfaces. See Table 39 on page 118 for more information.

Note

We recommend you follow this procedure to allow for future wiring considerations.

1. If applicable, remove the protective cover that is inserted into the RJ-21 end of the NIC Access Module cable.

2. Firmly insert the RJ-21 end of the cable into the connector labeled 1 on the NIC Access Module in slot 5 (see Figure 17 on page 49).

3. Tighten the two cable retainer screws by applying 4 in-lb of torque to each of the screws.

4. Locate the PORT 5 and PORT 6 connectors of the NIC Access Module cable and plug them into the Eth0 and Eth1 ports of the HFC Connector Module or SIM in slot 1 (see Figure 18 on page 51 and Figure 20 on page 54 for port labeling). If an HFC Connector Module or SIM is installed in slot 2, proceed to step 5; otherwise, proceed to step 15.

5. Locate the PORT 7 and PORT 8 connectors of the NIC Access Module cable and plug them into the Eth0 and Eth1 ports of the HFC Connector Module or SIM in slot 2. If an HFC Connector Module or SIM is installed in slot 3, proceed to step 6; otherwise, proceed to step 15.

6. Locate the PORT 9 and PORT 10 connectors of the NIC Access Module cable and plug them into the Eth0 and Eth1 ports of the HFC Connector Module or SIM in slot 3. If an HFC Connector Module or SIM is installed in slot 4, proceed to step 7; otherwise, proceed to step 15.

7. Locate the PORT 11 and PORT 12 connectors of the NIC Access Module cable and plug them into the Eth0 and Eth1 ports of the HFC Connector Module or SIM in slot 4. If an HFC Connector Module or SIM is installed in slot 10, proceed to step 8; otherwise, proceed to step 15.

8. If you have reached this step in the procedure, at least five HFC Connector Modules or SIMs are installed in the G10 CMTS, and a second NIC Access Module and its corresponding cable are required to complete the interconnection procedure. If applicable, remove the protective cover that is inserted into the RJ-21 end of the NIC Access Module cable.

9. Firmly insert the RJ-21 end of the second NIC Access Module cable into the connector labeled 1 on the NIC Access Module in slot 9 (see Figure 17 on page 49).

10. Tighten the two cable retainer screws by applying 4 in-lb of torque to each of the screws.

11. Locate the PORT 5 and PORT 6 connectors of the NIC Access Module cable and plug them into the Eth0 and Eth1 ports of the HFC Connector Module or SIM in slot 10. If an HFC Connector Module or SIM is installed in slot 11, proceed to step 12; otherwise, proceed to step 15.

12. Locate the PORT 7 and PORT 8 connectors of the NIC Access Module cable and plug them into the Eth0 and Eth1 ports of the HFC Connector Module or SIM in slot 11. If an HFC Connector Module or SIM is installed in slot 12, proceed to step 13; otherwise, proceed to step 15.

13. Locate the PORT 9 and PORT 10 connectors of the NIC Access Module cable and plug them into the Eth0 and Eth1 ports of the HFC Connector Module or SIM in slot 12. If an HFC Connector Module or SIM is installed in slot 13, proceed to step 14; otherwise, proceed to step 15.

14. Locate the PORT 11 and PORT 12 connectors of the NIC Access Module cable and plug them into the Eth0 and Eth1 ports of the HFC Connector Module or SIM in slot 13.

15. Ensure that all the Fast Ethernet ports of the HFC Connector Modules or SIMs are connected to the NIC Access Modules. Figure 37 on page 117 provides an illustration of these connections (without the coaxial cables shown).

16. Dress and route all used and unused Ethernet cable wires on all NIC Access Module cables to avoid obstructing the rear connections of the CMTS.

Table 39 on page 118 summarizes the NIC Access Module wiring plan used in this procedure. The Module – Slot / Port headings specify the HFC Connector Module name, the slot in which the module is installed, and the Fast Ethernet port label of the module.

Figure 37: NIC Access Module Cable Connections

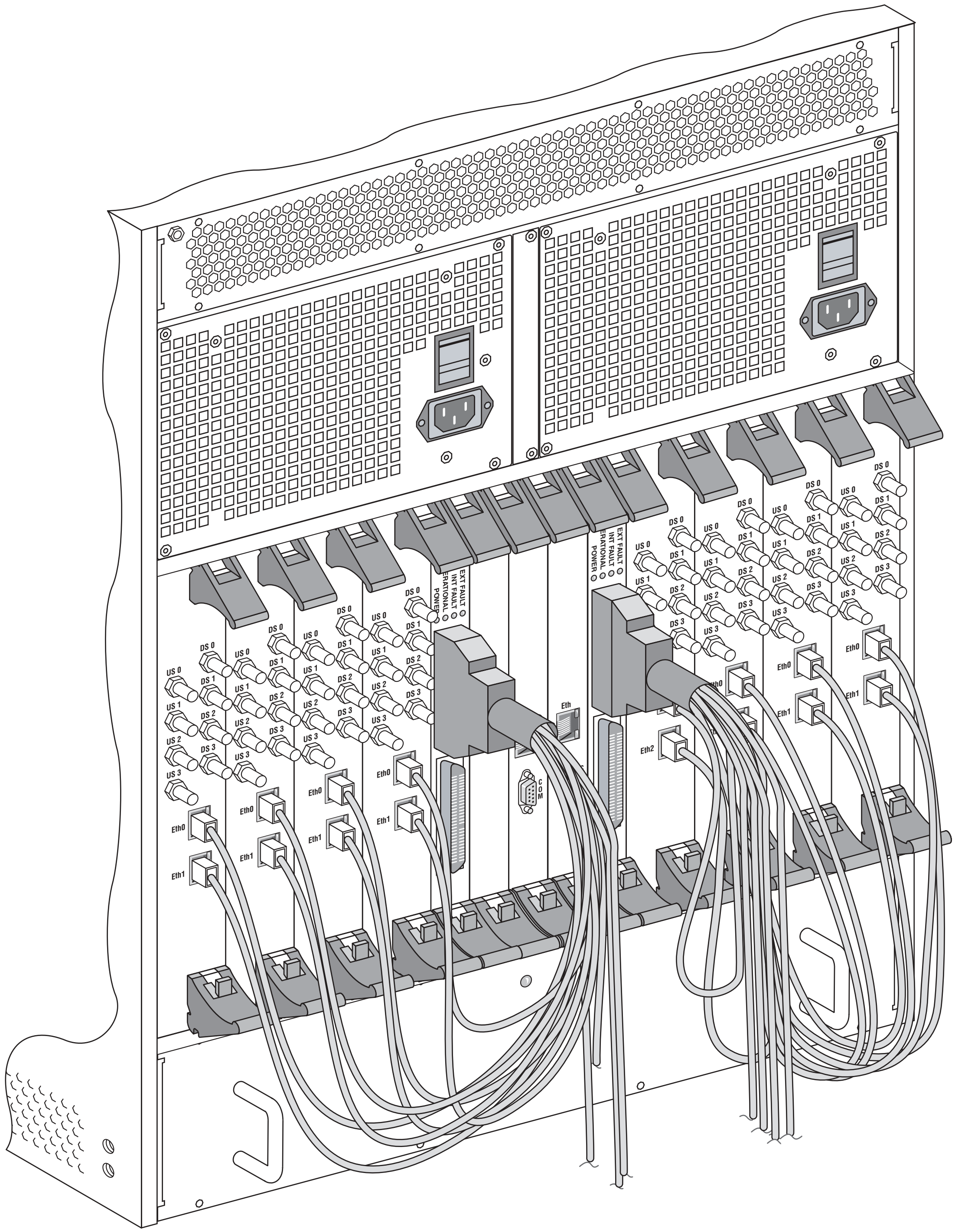


Table 39: NIC Access Module Wiring Plan

NIC Access Module in Slot 5		NIC Access Module in Slot 9	
NAM Cable / Port	**Rear Module – Slot / Port**	**NAM Cable / Port**	**Rear Module – Slot / Port**
Cable 1 / PORT 1	Reserved	Cable 1 / PORT 1	Reserved
Cable 1 / PORT 2	Reserved	Cable 1 / PORT 2	Reserved
Cable 1 / PORT 3	Reserved	Cable 1 / PORT 3	Reserved
Cable 1 / PORT 4	Reserved	Cable 1 / PORT 4	Reserved
Cable 1 / PORT 5	HFC or SIM – 1 / Eth0	Cable 1 / PORT 5	HFC or SIM – 10 / Eth0
Cable 1 / PORT 6	HFC or SIM – 1 / Eth1	Cable 1 / PORT 6	HFC or SIM – 10 / Eth1
Cable 1 / PORT 7	HFC or SIM – 2 / Eth0	Cable 1 / PORT 7	HFC or SIM – 11 / Eth0
Cable 1 / PORT 8	HFC or SIM – 2 / Eth1	Cable 1 / PORT 8	HFC or SIM – 11 / Eth1
Cable 1 / PORT 9	HFC or SIM – 3 / Eth0	Cable 1 / PORT 9	HFC or SIM – 12 / Eth0
Cable 1 / PORT 10	HFC or SIM – 3 / Eth1	Cable 1 / PORT 10	HFC or SIM – 12 / Eth1
Cable 1 / PORT 11	HFC or SIM – 4 / Eth0	Cable 1 / PORT 11	HFC or SIM – 13 / Eth0
Cable 1 / PORT 12	HFC or SIM – 4 / Eth1	Cable 1 / PORT 12	HFC or SIM – 13 / Eth1
Cable 2 / PORT 1	Reserved	Cable 2 / PORT 1	Reserved
Cable 2 / PORT 2	Reserved	Cable 2 / PORT 2	Reserved
Cable 2 / PORT 3	Reserved	Cable 2 / PORT 3	Reserved
Cable 2 / PORT 4	Reserved	Cable 2 / PORT 4	Reserved
Cable 2 / PORT 5	Reserved	Cable 2 / PORT 5	Reserved
Cable 2 / PORT 6	Reserved	Cable 2 / PORT 6	Reserved
Cable 2 / PORT 7	Reserved	Cable 2 / PORT 7	Reserved
Cable 2 / PORT 8	Reserved	Cable 2 / PORT 8	Reserved
Cable 2 / PORT 9	Fast Ethernet or Unused	Cable 2 / PORT 9	Fast Ethernet or Unused
Cable 2 / PORT 10	Fast Ethernet or Unused	Cable 2 / PORT 10	Fast Ethernet or Unused
Cable 2 / PORT 11	Fast Ethernet or Unused	Cable 2 / PORT 11	Fast Ethernet or Unused
Cable 2 / PORT 12	Fast Ethernet or Unused	Cable 2 / PORT 12	Fast Ethernet or Unused

Note

You can use PORT 9 through PORT 12 on cable 2 as Fast Ethernet interfaces; otherwise, these connectors are unused. These ports correspond to Fast Ethernet interfaces fx-0/*slot*/0 through fx-0/*slot*/3, where the slot can be 5 or 9.

Attach a PC to the Chassis Control Module

You must directly connect a personal computer (PC) to the Chassis Control Module to perform the initial configuration of the G10 CMTS. Using the DB-9–to–DB-9 null modem serial cable supplied in the accessory kit, connect one end of the cable to the RS-232 DB-9 port labeled COM on the Chassis Control Module front panel (see Figure 15 on page 39) and connect the other end to the serial port on your PC.

> **Note**
> You might need an adapter to connect the DB-9 connector of the cable to the serial port of your PC (for example, a DB-9–to–DB-25 adapter).

Connect to Power Sources

> **Warning**
> Ensure that you have read and taken the safety precautions provided in "Prepare the Site" on page 67 prior to connecting an AC or DC power source to the CMTS.

AC Power

Each AC power transition module in the G10 CMTS chassis contains a standard IEC 15 A three-prong male AC power receptacle for connecting to an AC power source (see Figure 6 on page 13). Facing the rear of the chassis, the AC power transition modules on the right and left sides of the chassis independently support the power supplies in domain A and domain B.

> **Note**
> You must supply power from different circuits to domain A and domain B for power redundancy protection.

To connect the AC power transition modules to their power sources, follow this procedure (see Figure 38 on page 120):

1. Ensure that the rocker switch on each AC power transition module is in the OFF (O) position.

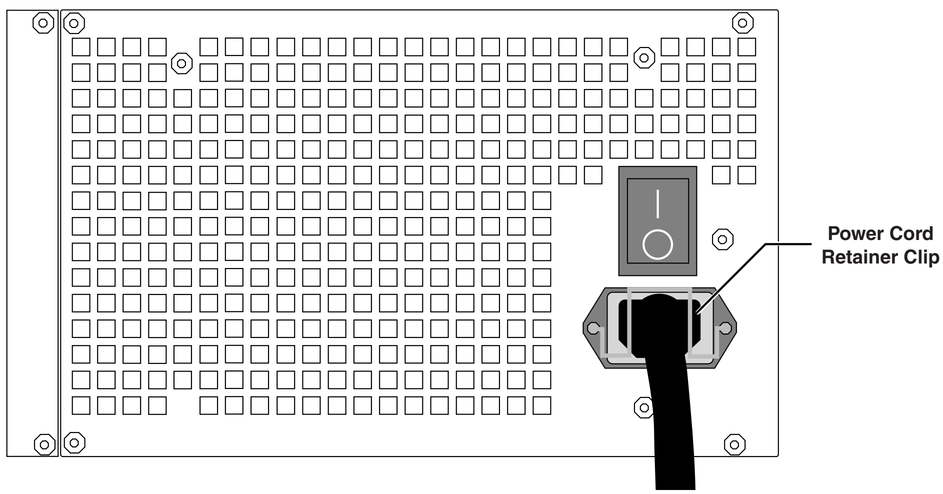
2. Swing the power cord retainer clips to their upright position and plug the female end of each 15 A power cord supplied with your shipment into the AC power receptacle on each AC power transition module.

3. Close the retainer clips so that they clasp around the power cords.

4. Plug the male end of each 15 A power cord into independent power sources. Always use AC power sources that support the ground prong of the power cord.

> **Note**
> The G10 CMTS power supplies are autosensing which enables them for usage with 115 VAC or 230 VAC.

Figure 38: AC Power Cord and Retainer Clip



DC Power

Each DC power transition module in the G10 CMTS chassis contains a terminal block for connecting to a DC power source (see Figure 39 on page 122). Unlike the AC configuration, the DC power transition modules do not operate independently. Each DC power transition module supports the power supplies in both domains of the chassis.

> **Note**
>
> You must supply power from different circuits to domain A and domain B for power redundancy protection.

To connect the DC power transition modules to their power sources, follow this procedure:

1. The G10 CMTS is shipped with ring lugs that are used to connect the DC power cord to the DC power transition module terminal block. You must crimp these ring lugs to the negative (–) and positive (+) wires of the DC power cord in order to properly connect to the DC power transition module.

> **Caution**
>
> We recommend you use 10–12 AWG wires for your power feeds unless your local safety code states otherwise.

2. Remove the plastic guard over the DC terminal block by loosening the two fastening screws until the guard can be removed by sliding it upward and over the two screws (see Figure 39 on page 122; the guard in this illustration is transparent so that you can see the terminal block). The guard will be reinstalled in step 7.

3. Remove the screw from the negative (–) terminal on the terminal block of the DC power transition module. Insert the screw through the ring lug of the power cord that will be attached to the negative (–) terminal of the DC power source and tighten the screw into the negative (–) terminal on the terminal block. Apply 20 in-lb of torque to the screw.

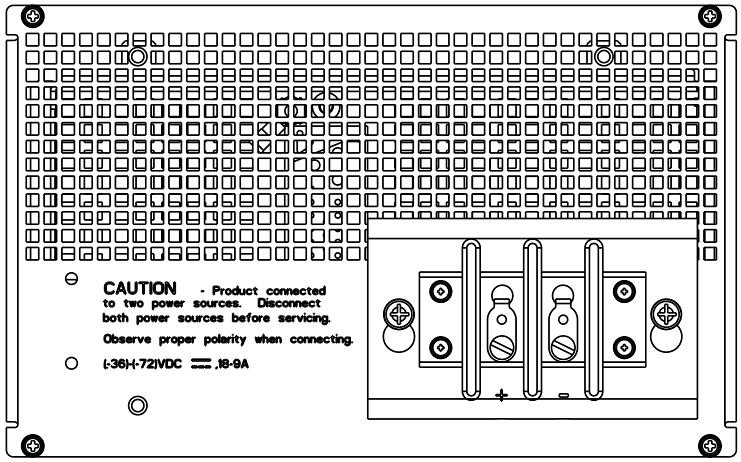
4. Remove the screw from the positive (+) terminal on the terminal block of the DC power transition module. Insert the screw through the ring lug of the power cord that will be attached to the positive (+) terminal of the DC power source and tighten the screw into the positive (+) terminal on the terminal block. Apply 20 in-lb of torque to the screw.

5. Connect the other end of the power cord connected to the negative (–) terminal on the terminal block of the DC power transition module to the negative (–) terminal of the DC power source in accordance with the manufacturer’s specifications.

6. Connect the other end of the power cord connected to the positive (+) terminal on the terminal block of the DC power transition module to the positive (+) terminal of the DC power source in accordance with the manufacturer’s specifications.

7. Replace the plastic guard over the two fastening screws and slide the guard down. Tighten the screws using a torque of 2.5 in-lb.

Figure 39: DC Power Transition Module



Chapter 6
Connect the Power and Perform Initial Configuration

It is assumed that you have followed the installation procedures described in “Install the CMTS” on page 93 prior to performing the procedures presented in this chapter.

This chapter discusses the following topics:

Power On the G10 CMTS

> **Caution**
> Ensure that you have read and taken the safety precautions in “Prepare the Site” on page 67 prior to powering on the G10 CMTS.

The following procedure defines the power-on procedure and the expected state of the LEDs on the power supplies, fan trays, and module panels after the CMTS is powered on.

1. Ensure that the power sources connected to the power transition modules are switched on.

2. If the CMTS is AC powered, press the rocker switch on each AC power transition module to the on (|) position (see Figure 38 on page 120). There is no requirement that the two power switches be turned on in any particular order. If the G10 CMTS is DC powered, the system will be powered up when the DC power transition modules have been connected to the DC power sources.

3. Remove the power supply faceplate by pulling the flanges on each side of the faceplate away from the chassis until the faceplate ball studs are removed from the power supply faceplate clips. Ensure that all power supplies are operating normally by checking that the Power LED is illuminated green and the Fault LED is not illuminated. If this is not the case, see Table 40 for a list of other LED combinations and the corresponding action to take.

Table 40: Power Supply LEDs

POWER	FAULT	Potential Meaning	Action
Green	Not illuminated	Normal operation	None
Green	Red	Over-temperature	■ Check that fan trays are operational (see step 5 on page 124). ■ Ensure all empty module slots and power supply bays contain air management modules, panels, and filler panels. ■ Ensure air intakes and exhaust are not blocked.
Green	Red	Over-current or over power limit condition	Ensure that the correct number of power supplies are installed to support the CMTS configuration.
Not illuminated	Red	Voltage input failure	Ensure that the external power sources are operating within specification.
Not illuminated	Not illuminated	■ Power supply not installed correctly. ■ No input power and no DC output from other power supplies to illuminate FAULT LED.	■ Power down the G10 CMTS and reinstall the power supply as described on "Install Power Supplies" on page 101. If power supply redundancy is implemented, you can replace a power supply without powering down the system. ■ Ensure that the external power sources are switched on.

Note: If the POWER LED is not illuminated, the FAULT LED can be illuminated red only if the DC output voltage is present from other power supplies.

4. Replace the power supply faceplate by aligning its four ball studs with the four power supply faceplate clips and pressing the faceplate towards the chassis until it snaps into place.

5. Ensure that the fan tray LEDs (two in front, one in rear) are not illuminated (see Figure 4 on page 11 and Figure 7 on page 14 for the location of these LEDs). If any fan tray LED is illuminated red, one or more fans in that tray has failed and you must replace the entire tray (see "Replace a Fan Tray" on page 162).

Caution: To minimize the risk of damage to the G10 CMTS, you should replace a failed fan tray as soon as possible to ensure that proper air ventilation occurs throughout the chassis.

6. Immediately after the G10 CMTS is powered on, check that the Test LED on every DOCSIS Module faceplate is green and blinking (see Figure 12 on page 30). This indicates that the module's self-test is running. Continue to monitor each module's Test LED until it stops blinking. If the Test LED is illuminated green, this indicates the successful completion of that module's self-test. If any module's Test LED is illuminated red, this indicates the self-test was not successful and you might have to replace the module (see "Remove a DOCSIS Module" on page 166). Table 41 indicates the expected status of all the LEDs on the module's front panel following the successful completion of the self-test.

Table 41: DOCSIS Module LED Status

LED	Status	Meaning
CPCI	Green Blinking	cPCI bus activity.
Test	Green	Self-test successful.
1	Green	Operating system initialization completed successfully on CPU0.
2	Green	Operating system initialization completed successfully on CPU3.
3	Green	Obtained boot instructions from Chassis Control Module.
4	Green	Operating system initialization completed successfully on CPU2.
5	Green	IP connectivity with Chassis Control Module established.
6	Green	Operating system initialization completed successfully on CPU1.
Eth0	Off	No link present.
Eth1	Off	No link present.
Activity 0	Off	No activity.
Activity 1	Off	No activity.
Link	Off	No link present.
10/100	Off	Off—10 MHz. On—100 MHz.
Hot Swap	Off	Not safe to remove module.

7. Immediately after the G10 CMTS is powered on, check that the Power LED on the Chassis Control Module faceplate is illuminated green (see Figure 15 on page 39). If the Power LED is illuminated red, this indicates a short circuit or over-current condition; you might have to replace the module (see "Remove a Chassis Control Module" on page 169). Table 42 indicates the expected status of all the LEDs on the module's front panel following power-on.

Table 42: Chassis Control Module LED Status

LED	Status	Meaning
Minor	Off	No event of priority Warning, Notice, Information, or Critical has occurred.
Major	Off	No event of priority Error has occurred.
Critical	Off	No event of priority Emergency, Alert, or Critical has occurred.
Run	Green	Module is active.
ACO	Off	Alarm Cutoff not activated.
Δ1 Δ2	Green	On—Active module. Off—Stand-by module.
IDE	Off	IDE inactive.
Power	Green	Power is applied.
USR1	[TBD]	[TBD]
USR2	[TBD]	[TBD]
Hot Swap	Off	Not safe to remove module.

8. Immediately after the G10 CMTS is powered on, wait for the OK LED on the NIC Module faceplate to illuminate green, which indicates the module initialization has been successfully completed (see Figure 16 on page 43). Some LEDs will be in one state during the initialization (OK LED not illuminated), then change to another state after the initialization (OK LED illuminated green). Table 43 on page 126 indicates the expected status of all LEDs on the module's front panel. If the OK LED does not illuminate, the NIC Module is considered faulty and you might have to replace it (see "Remove a NIC Module" on page 170).

Table 43: NIC Module LED Status

LED	Pre-initialization Status	Post-initialization Status	Meaning
Pull	Red	Off	Normal operation.
0 through 23	Off	Off	No link or activity on interfaces.
GB0 and GB1	Off	Off	No link on Gigabit interfaces.
CLK	Green	Off	Undefined.
PWR	Green	Green	Power is applied.
RTM	Green	Green	Continuity established with NAM.
OK	Off	Green	Successful initialization.
EXT FLT	Amber	Off	No external failure.
		Amber	One or more of the FE or GE ports is enabled, but unused.
INT FLT	Amber	Off	No internal failure.
Hot Swap	Off	Off	Not safe to remove module.

9. You should check the four LEDs at the top of the NIC Access Module rear panel after confirming the LEDs on its corresponding NIC Module are in the correct state as

described in step 8 (see Figure 17 on page 49). Table 44 indicates the expected status of all the LEDs on the NIC Access Module's rear panel following power-on. If the OPERATION LED is not illuminated green, the NIC Access Module is considered faulty and you might have to replace it (see the "Remove a NIC Access Module" on page 170).

Table 44: NIC Access Module LED Status

LED	Post-initialization Status	Meaning
POWER	Green	Power is applied.
OPERATIONAL	Green	Successful initialization.
INT FAULT	Off	No internal failure.
EXT FAULT	Off	No external failure.
	Amber	One or more of the FE or GE ports is enabled, but unused.

Note

Before you replace any module that appears to be faulty based on its LED status, contact Juniper Networks customer support for technical assistance.

Power On and Configure the PC

1. Power on the personal computer (PC) attached to the serial port of the Chassis Control Module.

2. Launch your asynchronous terminal emulation application (such as Microsoft Windows® Hyperterminal), and establish a direct connection. Configure the port settings as follows:

   - Bits per second: 9600
   - Data bits: 8
   - Parity: None
   - Stop bits: 1
   - Flow control: None

Perform Initial Software Configuration

When you receive the CMTS, the JUNOSg software is preinstalled and is ready to be configured after the CMTS successfully boots. The primary copy of the software is installed on a nonrotating flash disk and a backup copy is included on the CMTS's rotating hard disk on the Hard Disk Module. When the CMTS boots, it first attempts to start the image from the flash disk. If the boot from the flash disk fails, the CMTS attempts to boot from the hard disk.

Before you configure the CMTS, you need the following information:

- Name the CMTS will use on the network
- Domain name the CMTS will use
- IP address and prefix length information for the Ethernet interface
- IP address of a default CMTS
- IP address of a DNS server
- Password for the root user

To configure the software, follow this procedure:

1. After a successful connection is made between the PC attached to the serial port of the Chassis Control Module and the CMTS, the terminal emulation screen on your PC will display a banner and prompt you for a login username. Log in as the root user. There is no password.

2. Start the CLI.

```
root# cli
root@>
```

3. Enter configuration mode.

```
cli> configure
[edit]
root@#
```

4. Configure the name of the CMTS. If the name includes spaces, enclose the name in quotation marks (" ").

```
[edit]
root@# set system host-name host-name
```

5. Configure the CMTS's domain name.

```
[edit]
root@# set system domain-name domain-name
```

6. Configure the IP address and prefix length for the CMTS's Fast Ethernet management interface.

```
[edit]
root@# set interfaces fxp0 unit 0 family inet address address/prefix-length
```

7. Configure the IP address of a backup router, which is used only while the routing protocol is not running.

```
[edit]
root@# set system backup-router address
```

8. Configure the IP address of a DNS server.

```
[edit]
root@# set system name-server address
```

9. Set the root authentication password by entering either a clear-text password, an encrypted password, or an ssh public key string (DSA or RSA).

```
[edit]
root@# set system root-authentication plain-text-password
New password: password
Retype new password: password
or
[edit]
root@# set system root-authentication encrypted-password encrypted-password
or
[edit]
root@# set system root-authentication ssh-dsa public-key
or
[edit]
root@# set system root-authentication ssh-rsa public-key
```

10. Optionally, display the configuration to verify that it is correct.

```
[edit]
root@# show
system {
   host-name host-name;
   domain-name domain-name;
   backup-router address;
   root-authentication {
      authentication-method (password | public-key);
   }
   name-server {
      address;
   }
}
interfaces {
    fxp0 {
      unit 0 {
         family inet {
            address address/prefix-length;
         }
      }
   }
}
```

11. Commit the configuration. This activates the configuration on the CMTS.

```
[edit]
root@# commit
```

12. Optionally, configure additional properties by adding the necessary configuration statements. Then, commit the changes to activate them on the CMTS.

    ```
    [edit]
    root@host-name# commit
    ```

13. When you have finished configuring the CMTS, exit configuration mode.

    ```
    [edit]
    root@host-name# exit
    root@host-name>
    ```

The CMTS is now connected to the network but is not fully configured. You must perform additional configuration before the CMTS can pass traffic. For complete information about configuring the CMTS, including examples, see the JUNOSg software configuration guides.

Part 3
Troubleshooting and Maintenance

Chapter 7
RF Measurements

This chapter provides the procedures for measuring the downstream and upstream RF signals of a DOCSIS Module using a spectrum analyzer. You can follow these procedures immediately after the initial installation and configuration of the G10 CMTS to ensure the system is configured and operating properly. In addition, these procedures can assist you with the diagnosis of RF issues that are detected by spectrum monitoring applications such as the ServiceGuard Management System (see “ServiceGuard Management System” on page 147).

The procedures assume the use of a Hewlett Packard HP8591C CATV Analyzer, but any equivalent spectrum analyzer will suffice.

This chapter discusses the following topics:

Downstream RF Measurement in CATV Mode

This section describes the procedure for measuring the downstream signal power from the G10 CMTS using CATV mode on the HP8591C CATV analyzer. If your spectrum analyzer does not support CATV mode, you can use the spectrum analyzer mode as described in "Downstream RF Measurement in Spectrum Analyzer Mode" on page 135.

To measure the downstream signal power using CATV mode, follow this procedure:

1. Connect the spectrum analyzer to a cable within the plant that carries the downstream signal you are measuring. The signal originates from one of the downstream ports of the HFC Connector Module or the SIM (DS0 through DS3).

2. View (or set) the output RF power level of the specific interface to be measured. You can view the output power by issuing the show configuration command:

   user@host> **show configuration interfaces cd-***virtual-slot/docsis-slot/downstream-interface* **cable-options downstream**
   ```
   ...
   rf-power 61;
   ...
   ```

   In this example, the output RF power level is set to 61 dBmV. If the rf-power statement is not included in your configuration, the output RF power level defaults to 61 dBmV.

   To set the output RF power level for a downstream interface, include the rf-power statement at the [edit interfaces cd-*virtual-slot/docsis-slot/downstream-interface* cable-options downstream] hierarchy level:

   rf-power *rf-power*;

   The downstream interface power level can be from 50 dBmV through 61 dBmV.

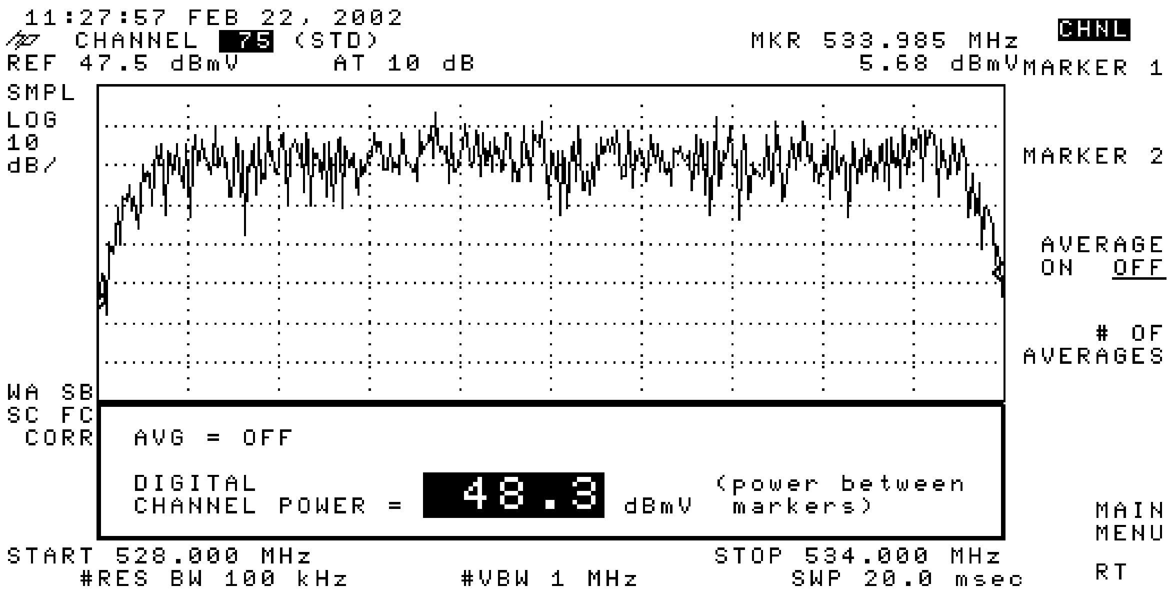
3. Press the MODE key and set the spectrum analyzer to CABLE TV ANALYZER mode.

4. Select CHANNEL MEAS (channel measurement) and enter the desired channel number. For example, select channel 75, which corresponds to a center frequency of 531 MHz.

5. Navigate to the third menu on the screen and select DIGITAL POWER. The spectrum analyzer display should be similar to the display in Figure 40 on page 135.

6. Ensure that the DIGITAL CHANNEL POWER shown at the bottom of the display is approximately equal to the configured downstream power level, minus any attenuation between the HFC Connector Module or SIM downstream port and the point at which your measurement is taken in the cable plant. In this example, assume the attentuation between the CMTS and the measurement point is approximately 13 dB. Therefore, the expected measured value should be approximately 48 dBmV.

Figure 40: Downstream RF Signal (CATV Mode)



Downstream RF Measurement in Spectrum Analyzer Mode

To measure the downstream signal power using the spectrum analyzer mode on the HP8591C CATV analyzer, follow this procedure:

1. Connect the spectrum analyzer to a cable within the plant that carries the downstream signal you are measuring. The signal originates from one of the downstream ports of the HFC Connector Module or the SIM (DS0 through DS3).

2. View (or set) the output RF power level of the specific interface to be measured. You can view the output power by issuing the show configuration command:

   user@host> **show configuration interfaces cd-***virtual-slot/docsis-slot/downstream-interface* **cable-options downstream**

   ```
   ...
   rf-power 61;
   ...
   ```

   In this example, the output RF power level is set to 61 dBmV. If the rf-power statement is not included in your configuration, the output RF power level defaults to 61 dBmV.

   To set the output RF power level for a downstream interface, include the rf-power statement at the [edit interfaces cd-*virtual-slot/docsis-slot/downstream-interface* cable-options downstream] hierarchy level:

   rf-power *rf-power*;

   The downstream interface power level can be from 50 dBmV through 61 dBmV.

3. Press the MODE key and set the spectrum analyzer to SPECTRUM ANALYZER mode.

4. Press the FREQUENCY key and enter the desired frequency (for example, 531 MHz).

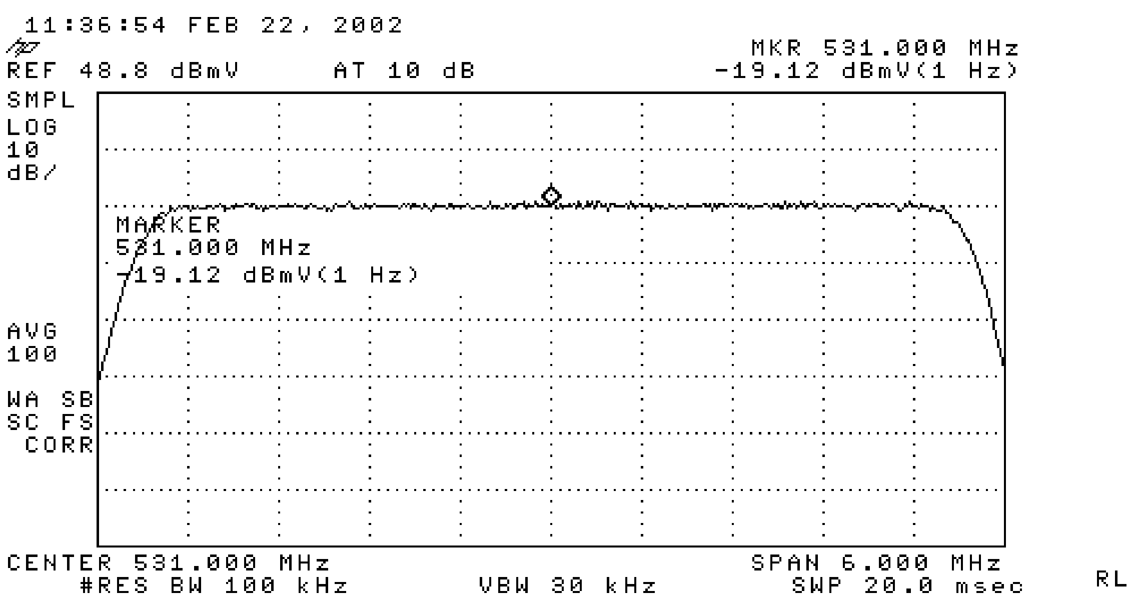
5. Press the SPAN key and enter 6 MHz.

6. Press the BW key and turn video averaging on by selecting VID AVG ON. The default number of averages is 100. You can change the number of averages by using the numeric keypad.

7. Press the MKR FCTN key (marker function) and select MK NOISE ON. This sets the spectrum analyzer to read out the power bandwidth, normalized to 1 Hz. The spectrum analyzer display should be similar to the display in Figure 41.

8. The power shown on the display in Figure 41—shown in the top/right and middle/left—is –19.12 dBmV, at 1 Hz. In order to obtain the power in the 6 MHz channel, a correction factor is required. This correction factor equals 10 log(ChannelBW/measurementBW). In this case, 10 log (6x10^6/1) equals 67.78 dB. Therefore, the actual downstream channel power equals (-19.12 dBmV + 67.78 dBmV), which equals 48.66 dBmV. Ensure that this power value is approximately equal to the configured downstream power level, minus any attenuation between the HFC Connector Module or SIM downstream port and the point at which your measurement is taken in the cable plant. In this example, assume the attentuation between the CMTS and the measurement point is approximately 13 dB. Therefore, the expected measured value should be approximately 48 dBmV.

Figure 41: Downstream RF Signal (Spectrum Analyzer Mode)



Upstream RF Measurement

To measure an upstream signal to the CMTS using zero span mode on the HP8591C CATV analyzer, follow this procedure:

> **Note**
>
> DOCSIS specifies that cable modems use TDMA (time division multiple access) for upstream transmissions, which means that cable modems are not continuously transmitting. In order to facilitate the triggering and capture of upstream signals, the cable modems should be transmitting long packets as often as possible.

1. Connect the spectrum analyzer to a cable within the plant that carries the upstream signal you are measuring. The signals are received on one of the upstream ports of the HFC Connector Module or SIM (US0 through US3).

2. Press the FREQ key and enter the center frequency that corresponds to the upstream frequency you are measuring. You can view the upstream frequency by issuing the show configuration command:

   user@host> **show configuration interfaces cu-***virtual-slot***/***docsis-slot***/***upstream-interface* **cable-options upstream**

   ```
   ...
   frequency 9m;
   ...
   ```

   In this example, the upstream frequency is set to 9 MHz.

3. Press the SPAN key and enter 0 MHz (or select ZERO SPAN). This sets the spectrum analyzer to zero span mode, which means that signals will be displayed in the time domain.

4. Press the BW key (bandwidth), select RES BW MAN (resolution bandwidth manual), and enter 3 MHz.

5. While in the BW key menu, select VID BW MAN (video bandwidth manual), and enter 3 MHz.

6. Press the AMPLITUDE key, select ATTEN MAN (attenuation manual), and enter 0 dB. This removes all internal spectrum analyzer attenuation.

7. While in the AMPLITUDE screen, select REF LVL (reference level), and enter a value slightly greater than the maximum power level you are expecting. The reference level is the power represented by the top graticule line in the display. Assume the reference level is set to 5 dBmV.

8. Select SCALE and adjust the scale so that the signal spans the entire Y-axis of the display.

9. Press the TRIG key (trigger), select VIDEO, and adjust the trigger line to within one graticule of the peak of the signal.

10. Press the SWEEP key, select SWP TIME MAN (sweep time manual), and set the sweep time to a value in the range of 80 through 100 microseconds.

11. Press the SGL SWP key (single sweep) repeatedly until the spectrum analyzer display is similar to the display in Figure 42 on page 138. The first three graticule columns represent the upstream burst transmission of a single cable modem, including the preamble.

12. Press the MKR (marker) key and adjust the marker to a position on the signal that represents the median power level of the signal. In Figure 42, the marker is approximately positioned at a median level of 0.65 dBmV. Ensure that this power level is equal to the commanded receive power level at the CMTS, plus any attenuation between the CMTS and the point of measurement.

    You can view the commanded receive power level by issuing the show configuration command:

    user@host> **show configuration interfaces cu-***virtual-slot***/***docsis-slot***/***upstream-interface* **cable-options upstream**

    ```
    ...
    commanded-power-level 0;
    ...
    ```

    In this example, the commanded receive power level is set to 0 dBmV. If the commanded-power-level statement is not included in your configuration, the commanded receive power level defaults to 0 dBmV.

Figure 42: Single Upstream Burst

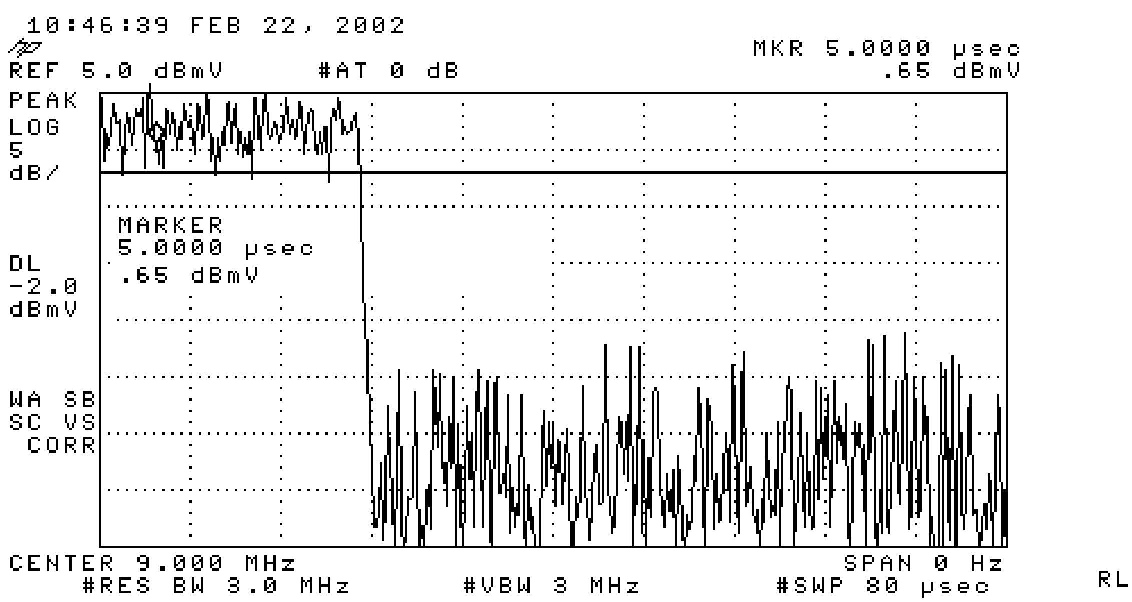
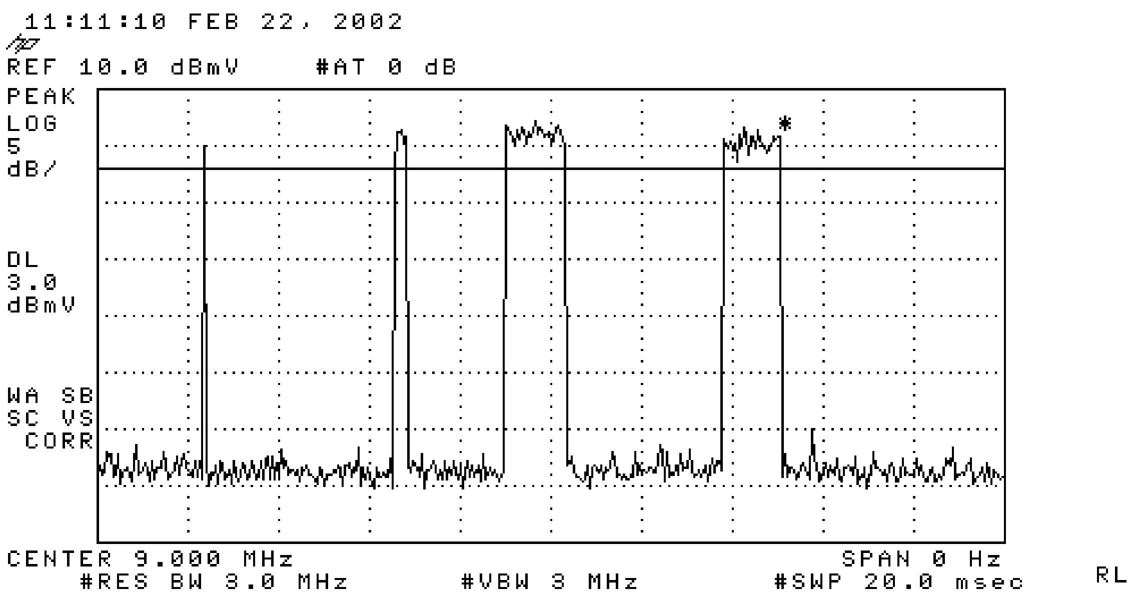


Figure 43 represents the spectrum analyzer display of multiple upstream bursts. This display was produced by repeating this procedure with the following modifications:

- The reference level in step 7 was set to 10 dBmV.
- The sweep time in step 10 was set to 20 milliseconds.

Figure 43: Multiple Upstream Bursts



Chapter 8
Troubleshooting

This chapter identifies common issues associated with the operation and configuration of the G10 CMTS, the HFC plant, and cable modem provisioning. Recommendations for troubleshooting and resolving these issues using the flap list are also provided. For purposes of discussion, *HFC plant* refers to all cabling and equipment on the RF side of the network, other than the CMTS, regardless of its physical location.

> **Note**
> We recommend that you review the G10 CMTS software and hardware release notes for details regarding the latest features, changes, and known and resolved issues. This might assist you with troubleshooting some of the issues you encounter with the operation of your system.

This chapter discusses the following topics:

Features for Troubleshooting

The G10 CMTS provides powerful features that aid you with troubleshooting CMTS, cable modem, and HFC plant related issues, including the flap list, the local event log, and various CLI commands that display relevant statistics.

This section discusses the following topics:

Flap List

The CMTS maintains a database of cable modems, along with various statistics for each cable modem. When a cable modem exhibits behavior that matches pre-defined criteria—referred to as a *flap*—an entry is added to a table called a *flap list*. Each flap list entry contains the MAC address of the cable modem, along with additional modem statistics that can assist in determining why the cable modem flapped. You can display the flap list by issuing the show cable modem flaps command.

You can define global flap criteria or define flap criteria on an upstream interface basis. Flap criteria defined for an upstream interface override those set at the global level. If a parameter is not explicitly set, a flap is defined by its default value.

After an entry is added to the flap list for a cable modem, any subsequent flap for that cable modem, whether defined explicitly or by default, updates that flap list entry with new statistics (including a flap count). Examples of flaps include excessive initial ranging, missed station maintenance opportunities, large upstream power adjustments, and an SNR dropping below a threshold.

The flap list can be used to assist you with troubleshooting, locating CMTS and cable modem configuration issues, and locating problems in the HFC plant without impacting throughput and downstream performance, and without creating additional packet overhead throughout the HFC network.

For more information about the flap list, see the *JUNOSg Software Configuration Guide: Interfaces, Cable, Policy, and Routing and Routing Protocols.*

Use the Flap List for Troubleshooting

To display the flap list, issue the show cable flap-list command:

```
user@host> show cable flap-list

MAC-Address        Interface Us/Port     IM     SM   PAdj   FAdj    SNR    MER
CER LTime           LEvnt        Total  FAdjAmnt  SNRavg  MERavg  CERavg
00:20:40:BF:5B:C4  ca-0/2/1   2/1         0      0      1      0      0      0
0 Feb 18 12:04:21 PADJ FLAP        1         0     33     23      0
00:E0:6F:03:16:DB  ca-0/2/0   9/0         0      0     13      0      0      0
0 Feb 18 12:04:28 PADJ FLAP       13         0     28     24      0
```

Table 45 on page 143 provides potential HFC plant issues associated with some of the flaps and statistics displayed in the output fields. The quantification of the flap counts and statistics is plant dependent, so general qualifications, such as *High* and *Low*, are provided.

Table 45: Flap List Association to Potential Issues

Output Field	Value	Potential Issues
IM (initial maintenance retry flaps)	High	■ DHCP server issues ■ TFTP server issues ■ Configuration file issues
SM (missed station maintenance flaps)	High	■ Noise ■ Ingress ■ Impairments such as common path distortion ■ Laser clipping distortion ■ Attenuation (too large or too small)
CER (codeword error rate flaps)	High (with low CERavg)	■ Impulse noise
CERavg (average CER)	High	■ Ingress ■ Impulse noise ■ Impairments such as common path distortion ■ Laser clipping distortion
PAdj (power adjust flaps)	High	■ High attenuation in the return path ■ Changing environmental conditions that affect the return path such as temperature ■ Improper amplification ■ Poor amplifier performance
FAdj (frequency adjust flaps)	High	■ Significant frequency error introduced by frequency stacking multiplexer (sometimes called *block upconversion*) in the return path ■ Degraded frequency stability in cable modem

SNRavg (SNR average)	Low	■ Increase in return path noise due to:
		  ■ Amplifier thermal noise
		  ■ Fiberoptic link noise
		  ■ Ingress noise
		■ High attenuation in the return path

MERavg (MER average)	Low	Any issues that affect the phase and amplitude of the signal in the return path: ■ Noise ■ Impairments ■ Non-linear distortions (in lasers and amplifiers, for example) ■ Linear distortions such as group delay variance ■ Quality of cable modem transmitter

You should consider the following general guidelines when interpreting the flap list statistics:

- If the flap list statistics are the opposite of the values presented in Table 45, the provisioning and the HFC plant conditions are considered satisfactory. Use these values to establish an operational baseline.
- If you sort the flap list by the total number of flaps, or by a specific flap, you can locate problematic nodes in the HFC plant. For example, if the flap list is sorted by MERavg and the flap entries with the lowest MERavg values are all within the same cable interface, your diagnostic procedures can focus on a particular area of the return path.
- If you sort the flap list by MAC address (by-mac), you can reveal issues associated with cable modems manufactured by the same vendor. You can determine this by inspecting the unique vendor identifier contained in the first 24 bits of the MAC address.
- MERavg provides a good metric for the overall quality of the return path because it is affected by virtually every possible source of QPSK and QAM signal amplitude and phase distortion (unlike other metrics are affected mostly by noise). You can use MERavg to gauge the margin of failure available within a particular upstream interface.
- If the IM value is high and the SM value is low, the cable modem might be having problems with the following:
    - Initial ranging due to CMTS configuration issues.
    - Initial ranging due to HFC plant issues in the forward path or the return path.
    - Registration due to provisioning issues.
    - Stability.
- If the IM value is low and the SM value is high, then the cable modem is able to successfully register, but there might be intermittent HFC plant issues in the forward path or the return path that cause the cable modem to use periodic maintenance opportunities unsuccessfully.
- A high PAdj value indicates that a cable modem's power adjustment is changing by a significant amount, which suggests problems in the return path. Compare PAdj for cable modems that reside before and after an amplifier in the return path to provide an indication of amplifier issues. High power levels of an RF signal can lead to laser clipping, which results in corrupted codewords as seen by the CMTS. Therefore, a high PAdj value in conjunction with a high CERavg value might provide an indication of laser clipping.
- A high FAdj value can occur when you use a frequency stacking multiplexer (sometimes called *block upconversion*) in which multiple upstream spectrums are stacked in frequency at the fiber node in the upstream, and there is significant frequency error introduced in the upconversion and downconversion process. Cable modems that have degraded frequency stability also cause frequency adjust flaps to occur.

Local Event Log

The local event log of the CMTS corresponds to the docsDevEventTable within the DOCS-CABLE-DEVICE-MIB (RFC 2669). This log can assist you with troubleshooting various issues. The OSSI specification defines required events that a CMTS must support. In addition, the G10 CMTS supports vendor-specific events.

To view the log, issue the show log cable command. Table 46 provides the correspondence between the display output fields and the DOCS-CABLE-DEVICE-MIB objects.

```
user@host> show log cable

Time shown as :      YYYY:MM:DD:HH:MM:SS:DS

Index Date/Time              Level       Id         Description
----- --------------------- ----------- ---------- ---------------------
5     2003:04:16:11:55:37:07 information 2539850802 FLAPLIST CM aged/cleared out
of flaplist on interface cable:2/0,CM MAC:00:00:39:A1:8A:4F,Upstream
Ch:1,Upstream Port:0
4     2003:04:15:10:54:51:03 notice      2539850801 FLAPLIST CM added to
flaplist on interface cable:2/0,CM MAC:00:00:39:A1:8A:4F,Upstream Ch:1,Upstream
Port:0,Condition:IRng
3     2003:04:15:10:54:31:05 information 2539850204 CHASSIS Module at slot 2
went online
2     2003:04:15:10:54:10:00 information 2539850204 CHASSIS Module at slot 5
went online
```

Table 46: Local Event Log Headings Displayed

Output Field	DOCS-CABLE-DEVICE-MIB Object	Meaning
Index	docsDevEvIndex	Relative ordering in the event log.
Date/Time	docsDevEvFirstTime	The time the entry was created.
Level	docsDevEvLevel	The priority level of the event.
Id	docsDevEvId	Unique identifier used by the CMTS for the event type.
Description	docsDevEvText	A text description of the docsDevEvId.

See the DOCSIS OSSI specification and the DOCS-CABLE-DEVICE-MIB for more information about the docsDevEventTable. See the *JUNOSg Software Configuration Guide: Interfaces, Cable, Policy, and Routing and Routing Protocols* for more information about event management.

Operational Commands

The following CLI commands can assist you with troubleshooting issues by displaying various types of information, including cable modem operational states, chassis hardware status, error logs, physical layer statistics, and configuration data:

- show cable modem—Display a list of cable modems (registered and unregistered) and associated operational parameters.
- show cable modem connectivity—Display connectivity information for a list of cable modems.
- show cable modem counters—Display byte and packet counters for all active service flows for a list of cable modems. For DOCSIS 1.0 cable modems, the counters correspond to the equivalent primary service flows created corresponding to the primary class-of-service.
- show cable modem cpe—Display a table of known CPE devices behind a set of cable modems.
- show cable modem detail—Display detailed information for a cable modem with the specified IP address.
- show cable modem errors—Display error statistics for a list of cable modems.
- show cable modem flaps—Display flaps for a list of cable modems.
- show cable modem offline—Display a list of offline cable modems.
- show cable modem physical-statistics—Display physical layer (PHY) statistics for a list of cable modems.
- show cable modem qos-profile—Display a list of cable modems associated with the specified QoS profile ID (which corresponds to the docsIfCmtsServiceQosProfile object in the RF-MIBv2-04 MIB).
- show cable modem ranging-statistics—Display ranging statistics for a list of cable modems.
- show cable modem registered—Display a list of registered cable modems and associated operational parameters.
- show cable modem remote-query—Display the statistics specified by the *snmp-entity* option for a list of cable modems that are in the IP-complete or registration-complete states.
- show cable modem rogue—Display a list of cable modems that have been declared rogue. The entity displayed corresponds to the pbcCmtsRogueCmTable object in the PBC-CMTS-MIB MIB.
- show cable modem subscriber-group—Display subscriber group information for a list of cable modems.
- show cable modem summary—Display a summary of cable modems in each operational state.

- show cable modem unregistered—Display a list of unregistered cable modems and associated operational parameters.
- show chassis environment—Display environmental information about the CMTS chassis, including the temperature of each DOCSIS Module, temperature thresholds, and fan and power supply status.

See the *JUNOSg Software Operational Mode Command Reference* for more information about these commands.

ServiceGuard Management System

> **Note:** The ServiceGuard Management System is an optional tool that is not part of the standard G10 CMTS shipment. A ServiceGuard Management System application must be purchased to take advantage of this powerful diagnostic aid.

You can perform spectrum monitoring of the HFC return path by using the ServiceGuard Management System. The ServiceGuard Management System provides a headend technician with an integrated tool to monitor and analyze the return path network performance at the G10 CMTS by collecting measurements gathered by the Broadband Cable Processor ASIC, processing them into useful statistical information, and presenting them graphically. Statistics that you can be measure and plot within the ServiceGuard Management System include noise power and noise power density, signal-to-noise ratio (SNR), modulation error rate (MER), and codeword error rate (CER).

The ServiceGuard Management System incorporates an integrated impairment identification tool that monitors statistics to characterize compromised performance to a potential cause (such as impulse or burst noise, narrowband ingress, or microreflections).

This application allows you to recognize, identify, and troubleshoot issues with the return path. In addition, you can use this application to map and allocate spectrum for upstream interfaces.

CMTS Power and Booting Issues

This section lists the following issues associated with powering up and booting the CMTS, along with procedures to resolve them:

CMTS Is Not Powering Up

If it appears that power is not being applied to the CMTS—because you do not hear or see any fans rotating, or do not see any LEDs illuminated—the cause might be one or more of the following:

- The power cords are not securely connected to the power transition modules and to their power sources.
- The power switches and the power sources are not turned on.
- The power supplies have failed. Note the status of the power supply LEDs. If the Power LED is not green or if the Fault LED is illuminated, take the appropriate actions described in Table 40 on page 124.

CMTS Does Not Boot Successfully

If you do not get to the login and password prompts, the CMTS did not successfully boot up. The cause might be one or more of the following:

- A new module added to the system might not be properly installed into the midplane of the chassis. See "Install the CMTS" on page 93 for more information.

> **Note**
>
> When you install a rear chassis module, apply more pressure to the upper ejector than to the lower ejector. This ensures the module connectors on the top of the card edge are properly aligned with the midplane connectors. The bottom edge has no connectors, so you do not need to press the rear ejector as firmly.

- The CMTS does not have at least one DOCSIS Module installed.
- A module is not operational. After you check that all modules are properly installed in the chassis, check their status LEDs to ensure they have powered up successfully. If you observe any of the following LED states, contact customer support:
  - The Power LED of a Chassis Control Module remains red indefinitely.
  - The Test LED of any DOCSIS Module remains red indefinitely.
  - Any of the 1 through 6 LEDs of any DOCSIS Module is not green.

  - The OK LED of a NIC Module does not illuminate.
  - The OPERATIONAL LED of a NIC Access Module does not illuminate.

> **Note**
> A faulty Chassis Control Module will prevent the CMTS from successfully booting up and might give the false appearance that the DOCSIS Modules and the NIC Modules are also faulty (based on their LED status). Determine the operational status of the Chassis Control Module before declaring any DOCSIS Modules or NIC Modules as faulty.

- The CMTS could not boot from the flash disk. When the CMTS boots, it first attempts to start the software image from the flash disk. If this fails, you can remove the flash disk to force the CMTS to boot from the hard disk. Contact customer support for learn how to remove the flash disk. Normally, you want the CMTS to boot from the flash disk.
- The CMTS was powered down and powered up in quick succession. We recommend that you wait at least 10 seconds after powering down the CMTS before you power it up.

CMTS Powers Down

If the CMTS powers down, this might be caused by one or more of the following:

- Power has been disrupted to the system. See "CMTS Is Not Powering Up" on page 148.
- The power supplies in the CMTS have reached their over-temperature shutdown limit.

1. Check the ambient temperature in the headend or hub in which the CMTS resides. The air cooling system might not be fully operative, and the ambient operating temperature might have exceeded the maximum specification for the G10 CMTS of 40°C. See if an SNMP message was sent to the NMS or an entry was added to the event log indicating the temperature of the CMTS exceeded the high threshold (defined by the high statement).
2. Check that all empty module slots and power supply bays contain air management modules, panels, and filler panels. In addition, the power supply faceplate must always be installed while the CMTS is operating. These requirements ensure that proper air ventilation occurs throughout the chassis.
3. Ensure that proper clearance is maintained between the G10 CMTS chassis and its surroundings to allow adequate air ventilation to flow into the air intakes and out of the air exhaust. See "Rack Mounting" on page 94 for clearance details.
4. One or more of the fans within a fan tray might have stopped rotating while the CMTS was operating. If an SNMP message was sent to the NMS, an entry was added to the event log indicating a fan failure, or a fan tray LED was illuminated red before the CMTS powered down, you must replace the fan tray that contains the faulty fan.

Ideal HFC Plant Configuration Issues

This section provides a list of potential HFC plant issues and the procedures to resolve them. The troubleshooting procedures in this section assume that the HFC plant is ideal and not contributing to issues associated with the cable modems.

"HFC Plant Related Issues" on page 156 addresses issues associated with problems in the HFC plant.

This section includes the following topics:

Cable Modem Cannot Successfully Range

If a cable modem cannot successfully range, the cause might be one or more of the following:

- The downstream and upstream interface and port mapping are not properly aligned with the forward and return path topology of the HFC plant. For example, suppose a cable modem resides in cable interface 0 (MAC domain 0), which contains downstream interface 0 and upstream interfaces 0 and 1. Also, suppose the forward and return paths are connected to downstream port 0 and upstream port 0 of an HFC Connector Module or SIM. If you manually reconfigured the CMTS so that upstream interface 0 is moved to upstream port 1, but the interface still resides in cable interface 0, when upstream interface 0 is enabled, the CMTS will be expecting the cable modem to transmit on port 1, but the cable modem will be transmitting its ranging requests on port 0.
- The upstream interface on which the cable modem resides is not enabled.

A high IM value in the flap list can be an indication of ranging issues.

The local event log might contain events that explain why a cable modem has been de-ranged. Issue the show log cable command to see the local event log.

Cable Modem Cannot Establish IP Connectivity

If a cable modem cannot establish IP connectivity, the cause might be one or more of the following :

- The DHCP server could not be accessed because the network is down.
- The DHCP server is down. Ping the DHCP server IP address using the ping command to see if the server is responding.
- The DHCP server parameters are not properly configured within the CMTS.

A high IM value in the flap list can be an indication of DHCP setup issues.

Cable Modem Cannot Successfully Register

If a cable modem cannot successfully register, the cause might be one or more of the following:

- The cable modem did not receive a configuration file because:
  - The TFTP server could not be accessed because the network is down.
  - The TFTP server is down.
  - The name of the configuration file provided in the DHCP response was incorrect.
  - The TFTP server IP address provided in the siaddr field of the DHCP response was incorrect.
  - The TFTP server was hosting the maximum number of sessions when the cable modem requested the configuration file.
- The CMTS indicated an authentication failure in its REG-RSP message because:
  - The TFTP Server Timestamp field in the cable modem's REG-REQ message differs from the local time maintained by the CMTS by more than the CM Configuration Processing Time (the maximum time for a cable modem to send a REG-REQ message following the receipt of the configuration file, which must be a minimum of 30 seconds).
  - The TFTP Server Provisioned Modem Address field in the cable modem's REG-REQ message does not match the requesting cable modem's actual address.
  - The message integrity check (MIC) was not valid because the shared secret between the CMTS and the provisioning server did not match, which results in an authentication failure.
  - The MIC was not valid because the configuration file was modified en route between the provisioning server and the cable modem.

  Issue the show log cable command to see if the CMTS made an entry for an authentication failure in the local event log.

- The cable modem received a configuration file, but the contents of the file are not valid. Ensure the configuration settings are valid and are consistent with the DOCSIS specifications.

- The cable modem timed out waiting for the time of day (TOD) server to respond. Newer cable modems continue the registration process while continuing to retry the TOD request. However, some older cable modems do not attempt to register if they time out while waiting for a TOD response. The TOD timeout might occur if the TOD server IP address provided in the DHCP response was incorrect.

A high IM value in the flap list can be an indication of TFTP, configuration file, or registration issues.

Cable Modem Throughput is Slow

If the throughput of a cable modem seems slow, the cause might be one or more of the following:

- The DOCSIS 1.0 Class of Service Configuration Setting (for DOCSIS 1.0) or the Upstream Service Flow Configuration Setting and the Downstream Service Flow Configuration Setting fields (DOCSIS 1.1) of the configuration file are limiting the maximum upstream and downstream bandwidth of the cable modem. If necessary, increase the parameters within these fields in the configuration file to increase the cable modem's throughput.

  To determine the maximum bandwidth settings for a cable modem, issue the show cable modem command to determine the QoS profile for a cable modem:

  user@host> **show cable modem**

```
Interface Us Prim  Online     Timing Rec   QoS BPI IP-Address     MAC-Address
Reg Modul
             Sid   State       Offset Power
ca-0/2/0   0   36  init(rc)      585   0.0    1 Off 10.27.1.101
00:40:36:09:44:EB 1.0 TDMA
```

  In this example, the cable modem uses QoS profile 1. Then issue the show cable qos-profile command to display the characteristics of QoS profile 1:

  user@host> **show cable qos-profile 1**

```
Service  Prio        Max  Guarantee         Max  Max tx  Create Baseline
class           upstream   upstream  downstream   burst      by  privacy
               bandwidth  bandwidth   bandwidth                   enable
      1     0    1000000          0    10000000       0    cmts      no
```

  The cable modem's maximum upstream bandwidth is 1 Mbps and its maximum downstream bandwidth is 10 Mbps.

- The cable modem belongs to a downstream or upstream interface on which a traffic scheduling policy is assigned. Packets that exceed the maximum sustained traffic rate (MSTR) are dropped or shaped, depending on the traffic scheduling policy configuration. Issue the **show cable policy traffic-scheduling** command to display configured traffic scheduling policies.

- The cable modem belongs to a downstream or upstream interface on which a congestion control policy is assigned, such as random early detection (RED), leading to dropped packets. Issue the **show cable policy congestion-control** command to display configured congestion control policies.

- Congestion exists in the upstream.

  You can compute the approximate upstream channel utilization by monitoring the **ifInOctets** object in the DOCS-IF-MIB (RFC 2670). The **ifInOctets** object contains the total number of octets received on an interface, including data packets as well as MAC layer packets, and includes the length of the MAC header. However, this object does not account for the PHY layer overhead—preamble, FEC, and guard time—which consumes a certain percent of the available raw channel bandwidth. The following procedure explains how to compute the approximate upstream channel utilization using an SNMP MIB browser:

  1. Set the SNMP polling time to a value large enough to capture a statistically significant amount of upstream traffic. In this example, assume the polling time is 60 seconds.

  2. Browse the **ifInOctets** object for the interface that corresponds to the upstream interface you are measuring. Wait for the value of the object to change and record this value. Assume the value is 33,019,041 octets.

  3. Wait 60 seconds for the value of the object to change and record this value. Assume the value is 65,903,162 octets.

  4. Subtract the value of the object measured in step 2 from the value measured in step 3 to obtain the number of octets received by the CMTS on this upstream interface over the polling time: (65,903,162–33,019,041 = 32,884,121 octets).

  5. Multiply the value computed in step 4 by eight (to convert to bits), then divide by the polling time to compute the upstream channel bandwidth (without the PHY overhead): [(32,884,121 octets * 8) / 60 sec] = 4,384,549 bps.

  6. Compute the maximum available raw bandwidth by multiplying the symbol rate of the channel by the number of bits/symbol. Assume the symbol rate is 2560 Ksym/sec, and the modulation is QPSK (2 bits/symbol), which yields a bandwidth of 5,120,000 bps.

  7. Computing the PHY overhead, and hence the channel efficiency, is a non-trivial exercise because it is dependent on the mix of transmissions that use a particular interval usage code, packet sizes, and the modulation profile and mini-slot size of the channel. Using practical values for these variables, assume a channel efficiency of 92 percent (be aware that the channel efficiency can be lower depending on the assumptions made). Derating the maximum available raw bandwidth of the channel by 92 percent yields 4,710,400 bps (5,120,000 bps*0.92).

8. You can compute the approximate upstream channel utilization by dividing the measured bandwidth calculated in step 5 by the derated maximum bandwidth calculated in step 7: (4,384,549 / 4,710,400) = 93 percent. This represents a highly utilized interface.

Congestion might be attributed to one or more of the following:

- An excessive number of cable modems are attached to a DOCSIS Module in the return path of the HFC plant. Review your corporate guidelines to ensure you have not exceeded the maximum number of cable modems per DOCSIS Module for the modulation profiles being used. If necessary, install additional DOCSIS Modules.

- An excessive number of cable modems are assigned to the upstream interface in which the cable modem transmits. Issue the show cable modem command as follows to determine the number of cable modems within an upstream interface:

user@host> **show cable modem summary total interface**
cu-*virtual-slot/ docsis-slot/ upstream-interface*

```
                         ---Cable Modem Operational States---
Interface Us    CM     Dstry  Dclr  Rng     Rng     Rng     IP      Reg   Access
                Qty                         Abort   Compl  Compl          Denied
ca-0/2/0   0     5         0     0     0       5       0      0        0        0
total            5         0     0     0       5       0      0        0        0
```

An excessive number of cable modems on an upstream interface can be addressed by the following:

  - Enable load balancing in the CMTS by including the load-balance statement at the [edit services cable upstream] hierarchy level. The CMTS attempts to assign a cable modem to an upstream channel based on channel width and utilization.

  - Provision one or more additional upstream interfaces in the cable interface in which the cable modem resides. The logical allocation of up to 16 upstream interfaces to any of the upstream ports on a DOCSIS Module allows you to provision interfaces without the need for physical node recombining.

  - Increase the upstream channel width.

- The cable modem is transmitting using QPSK modulation. The all-digital processing of the Broadband Cable Processor ASIC, along with its advanced noise cancellation and equalization algorithms, might allow the cable modems on an upstream channel to operate at 16QAM. To change the modulation of an upstream channel, assign a new modulation profile to that channel.

- Congestion exists in the downstream.

  You can compute the approximate downstream channel utilization by monitoring the ifOutOctets object in the DOCS-IF-MIB (RFC 2670). The ifOutOctets object contains the total number of octets transmitted on an interface, including data packets as well as MAC layer packets, and includes the length of the MAC header. However, this object does not account for overhead—such as FEC, MPEG, and DOCSIS MAC—which consumes a certain percent of the available raw channel bandwidth. The following procedure explains how to compute the approximate downstream channel utilization using an SNMP MIB browser:

  1. Set the SNMP polling time to a value large enough to capture a statistically significant amount of upstream traffic. In this example, assume the polling time is 60 seconds.

  2. Browse the ifOutOctets object for the interface that corresponds to the downstream interface you are measuring. Wait for the value of the object to change and record this value. Assume the value is 383,456,157 octets.

  3. Wait 60 seconds for the value of the object to change and record this value. Assume the value is 563,344,189 octets.

  4. Subtract the value of the object measured in step 2 from the value measured in step 3 to obtain the number of octets transmitted by the CMTS on this downstream interface over the polling time: (563,344,189–383,456,157 = 179,888,032 octets).

  5. Multiply the value computed in step 4 by eight (to convert to bits), then divide by the polling time to compute the downstream channel bandwidth: [(179,888,032 octets * 8) / 60 sec] = 23,985,071 bps.

  6. Compute the maximum available raw bandwidth by multiplying the symbol rate of the channel by the number of bits/symbol. Assume the symbol rate is 5.056941 Msym/sec, and the modulation is 64QAM (6 bits/symbol), which yields a bandwidth of 30,341,646 bps.

  7. Assuming a channel efficiency of 85 percent (due to overhead), derating the maximum available raw bandwidth of the channel yields 25,790,399 bps (30,341,646 bps*0.85).

  8. You can compute the approximate downstream channel utilization by dividing the measured bandwidth calculated in step 5 by the derated maximum bandwidth calculated in step 7: (23,985,071 / 25,790,399) = 93 percent. This represents a highly utilized interface.

  Congestion in the downstream might caused by an excessive number of cable modems attached to a DOCSIS Module in the forward path of the HFC plant. Review your corporate guidelines to ensure you have not exceeded the maximum number of cable modems per DOCSIS Module. If necessary, install additional DOCSIS Modules.

- The CMTS is transmitting using 64QAM modulation. If the HFC plant can support reliable downstream transmissions using 256QAM modulation, change the modulation to 256QAM.

- The performance on the network-side interface (NSI) is slow. Find the NSI bottleneck and address the performance issue appropriately.

- If the cable modem is a CCCM (CPE controlled cable modem), the performance of the CPE is affecting the performance of the cable modem. The CPE performance can be affected by one or more of the following:
  - A slow microprocessor.
  - Not enough RAM.
  - Not enough disk space.
  - Running too many applications.
  - Improper network configuration.

Cable Modem is Dropped

A cable modem might be dropped from the CMTS for the following reasons:

- The cable modem belongs to a downstream or upstream interface on which a call admission control (CAC) policy is assigned. If the ratio of the aggregate best-effort minimum reserved traffic rate (MRTR) for all admitted service flows to the channel bandwidth exceeds the ratio configured in the CAC policy, cable modems are dropped based on the traffic priority of their service flow until the ratio is not exceeded. Issue the show cable policy admission-control command to display configured CAC policies.
- You have changed the configuration for an interface that was previously configured with QoS parameters for admitted service flows based on the original interface configuration. For example, assume a CAC policy is configured with the maximum allowable ratio of the aggregate best-effort MRTR for all admitted service flows to the channel bandwidth at 50 percent. If the original channel bandwidth was 10 Mbps, but is reconfigured to 5 Mbps, the aggregate MRTR above which cable modems are dropped is reduced from 5 Mbps (50 percent of 10 Mbps) to 2.5 Mbps (50 percent of 5 Mbps).

HFC Plant Related Issues

This section assumes that the HFC plant is potentially contributing to issues associated with the cable modems. Following is a list of potential issues along with suggestions to resolve them.

This section includes the following topics:

Cable Modem Cannot Successfully Range

If a cable modem cannot successfully range, the cause might be one or more of the following:

- There is too much attenuation in the return path. If the power level of the cable modem's signal measured at the CMTS is not within the tolerable limits of the CMTS due to excessive attenuation, the CMTS responds with an abort ranging status in the ranging response (RNG-RSP) message to the cable modem.

  You can configure the power level below the commanded power level at which a cable modem is considered successfully ranged by including the minimum-power-level statement at the [edit services cable upstream] or [edit interfaces cu-*virtual-slot/ docsis-slot/ upstream-interface* cable-options upstream] hierarchy levels. The default is –3 dB below the commanded power level. Consider lowering this threshold to see if a cable modem can operate successfully at a lower power level.

  > **Note**
  > See the *JUNOSg Software Configuration Guide: Interfaces, Cable, Policy, and Routing and Routing Protocol* for important information about changing the minimum power level. Setting the value too low can lead to improper CMTS behavior.

- RF plant issues in the downstream prevent the cable modem from receiving unicast upstream bandwidth allocation MAP messages that define periodic ranging opportunities (station maintenance) for the cable modem. In this case, the cable modem will time out and reinitialize its MAC, causing it to drop offline.
- RF plant issues in the return path prevent the CMTS from receiving ranging request (RNG-REQ) messages, in which case the CMTS will not provide ranging response (RNG-RSP) messages. In this case, the cable modem will time out and reinitialize its MAC, causing it to drop offline.
- Significant frequency error is being introduced by the frequency stacking multiplexer (sometimes called block upconversion) in the return path.
- Frequency stability within the cable modem is degraded.

High IM, SM, and FAdj values in the flap list can be an indication of HFC plant issues that affect ranging (see Table 45 on page 143).

The local event log might contain events that explain why a cable modem has been deranged. Issue the show log cable command to see the local event log.

Issue the show cable modem ranging-statistics command to view ranging statistics that might provide insight into ranging issues.

Cable Modem Throughput is Slow

If the throughput of a cable modem seems slow, the cause might be one or more of the following:

- HFC plant issues, such as impulse noise or ingress, that corrupt upstream burst transmissions from the cable modem. A high CERavg value or a low MERavg value in the flap list is indicative of this. Uncorrectable codewords cause packets to be dropped by the CMTS, which reduces the cable modem throughput.

  If the CER value is high, but the CERavg value is low, this suggests that burst noise is occurring, but its duration is too short to render a codeword uncorrectable. However, you should investigate the source of the noise as part of your preventive HFC plant maintenance routine.

- HFC plant issues, such as impulse noise, that corrupt downstream transmissions to the cable modem. Increasing the depth of the interleaver can increase the amount of burst protection in the downstream. For example, the default interleaver depth using 64QAM modulation provides 5.9 microseconds of burst protection. You can increase the burst protection to 12, 24, 47, or 95 microseconds. Be aware that increasing the interleaver depth increases the latency of the transmission.

In general, a number of HFC-related issues can be responsible for the receipt of uncorrectable codewords at the CMTS. Table 45 on page 143 describes how to associate flap list statistics to the presence of these issues.

Issuing one or more of the following commands can provide you with additional insight into HFC-related issues that affect cable modem performance:

- show cable modem errors
- show cable modem flap
- show cable modem physical-statistics
- show cable modem remote-query

Chapter 9
Replacement Procedures

This chapter discusses the following topics related to the removal and replacement of CMTS hardware components:

> **Caution**
> Before replacing a power supply or any module from the CMTS, attach one end of an ESD ground strap to your wrist and attach the other end to the ESD ground strap jack on the front of the chassis (see Figure 5 on page 12).

Power Supplies

The G10 CMTS can operate in a power redundant or non-redundant configuration. Power redundancy consists of redundant power supplies, power transition modules, and power sources:

- Power supplies—The G10 CMTS can accommodate up to ten power supplies within domains A and B.
- Power transition modules—All G10 CMTS systems are shipped with two power transition modules installed in each of the two domains to implement power transition module redundancy. This also facilitates power source redundancy.
- Power sources—Each power transition module must be powered by sources on different circuits to implement power source redundancy.

When operating in a power-redundant configuration, a single power-related component can fail without affecting the operation of the CMTS. However, because the CMTS is no longer operating as a redundant system, we recommend that you replace the faulty component as soon as possible. The component can be hot-swapped without powering down the CMTS.

To determine if a power supply has faulted, check the status of the power supply LEDs. If the Power LED is not illuminate green, or if the Fault LED is illuminated, take the appropriate actions as described in Table 40 on page 124.

If the CMTS is not operating in a power-redundant configuration, a fault with a single power-related component might cause the CMTS to shut down.

> **Warning**
> If a fault does occur within a non-redundant configuration, we strongly recommended that you immediately switch off the power to the CMTS for safety purposes.

In the case of AC power, you switch off the power by pressing the rocker switch on the AC power transition module to the off (O) position. In the case of DC power, the DC power transition module does not contain a power switch. We recommend that you switch off the DC power before removing the DC power cord from the DC power transition module terminal block. Once the power is switched off, you can safely replace the faulty component.

Remove Power Supplies

The power supplies in the G10 CMTS are hot-swappable, which means that the system can remain powered up while a power supply is being removed or installed.

> **Caution**
> Before you hot-swap a power supply, ensure at least five operating power supplies remain in the chassis after you remove the faulty power supply. Otherwise, power down the CMTS before removing the faulty power supply.

The following procedure describes the steps required for removing a power supply:

1. Remove the power supply faceplate by pulling the flanges on each side of the faceplate away from the chassis until the faceplate ball studs are removed from the power supply faceplate clips.

2. Loosen the upper and lower retainer screws of the power supply.

3. Press down on the ejector release while simultaneously pulling the ejector away from the power supply (actions #1 and #2 in Figure 44 on page 161). The ejector should rest at approximately 45° from the faceplate. The power supply is physically and electrically removed from its connector on the midplane.

4. Slowly slide the power supply out of its bay until it is fully removed from the system (action #3 in Figure 44).

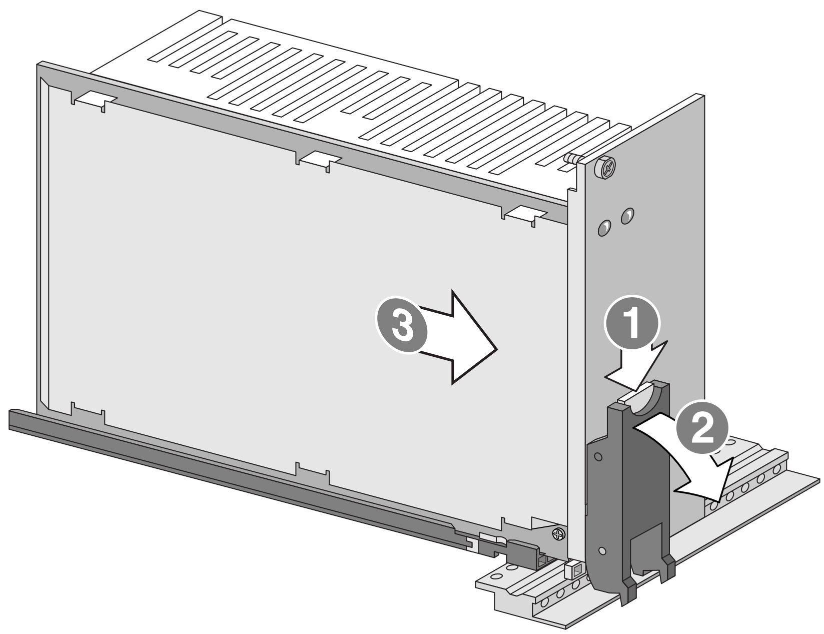
5. If you are not replacing the power supply, you must install a power supply filler panel to cover the empty power supply bay. Align the panel over the bay opening so that the two self-contained screws are on the left side of the panel when installed in the chassis (see Figure 5 on page 12). Apply 3 in-lb of torque to each of the two screws.

6. Replace the power supply faceplate by aligning its four ball studs with the four power supply faceplate clips and pressing the faceplate towards the chassis until it snaps into place.

> **Caution**
>
> The power supply faceplate and power supply filler panels must be installed before you power on the G10 CMTS to ensure that proper air ventilation occurs throughout the chassis, and to reduce EMI emissions.

See "Install Power Supplies" on page 101 for power supply installation instructions.

Figure 44: Power Supply Removal



Fan Trays

To maintain an internal temperature below the maximum operating temperature of the G10 CMTS, all fan trays must be fully functional. If any of the fan trays fails, you must replace it as soon as possible to ensure the CMTS remains operational.

You can detect a fan tray failure by any of following indicators:

- A fan tray LED is illuminated red.
- If enabled, an entry was written the local event log.
- If enabled, an SNMP message was sent to the NMS indicating a fan failure.
- The display produced by issuing the show chassis environment command shows a fan speed of 0 RPM.
- If enabled, an SNMP message was sent to the NMS indicating the temperature of the CMTS exceeded the temperature high threshold. This might also indicate the ambient temperature is rising.

Replace a Fan Tray

If a fan tray LED is illuminated red, one or more fans in that tray has failed and you must replace the fan tray. The fan trays are hot-swappable, which means you can remove and install them while the system is powered on.

If a fan tray fails to the point where inadequate air ventilation flows through the chassis, the Chassis Control Module might power down the system if the temperature within the chassis exceeds the threshold considered safe for system operation.

Caution

- All fans within a fan tray contain top and bottom grills to provide protection during removal and installation. Nevertheless, take care when inserting your hand anywhere in the vicinity of an operating fan.
- Operating the G10 CMTS without fully functional fan trays might cause irreparable damage or reduce the life of one or more modules in the system. After removing a fan tray, you must immediately install its replacement.

Front Fan Trays

To replace a front fan tray, follow this procedure (see Figure 45 on page 164).

1. Remove the air intake faceplate by pulling the flanges on each side of the faceplate away from the chassis until the faceplate ball studs are removed from the air intake faceplate clips.

2. Each fan tray is held into place by a front fan tray retainer that resides on hinges. The retainer contains a spring-loaded plunger that mates with the chassis when the retainer is locked into position. To unlock the retainer, pull down on its plunger and swing it away from the chassis until it comes to rest.

3. Grab the fan tray directly underneath the flange that houses its LED and slowly pull the tray out of its bay until it is fully removed from the system. Figure 45 shows a populated and an empty front fan tray bay in the chassis (the front fan tray retainer is not shown in the empty bay and the air intake faceplate clips are not shown in either bay).

4. Align the edges of the fan tray replacement within the chassis fan tray rails. Ensure that the fan tray edges are not seated above or below the rails, but are within the rails.

5. Slowly slide the fan tray completely into its bay until its power connector mates with its corresponding midplane power connector. You should be able to see and hear the fans operating within the tray.

6. You must return the front fan tray retainer to its locked position by pulling down on its plunger, swinging the retainer toward the chassis, and releasing its plunger so that it mates with the chassis. If the plunger cannot mate with the chassis, the fan tray is not fully installed into its bay.

7. Replace the air intake faceplate by aligning its four ball studs with the four air intake faceplate clips and pressing the faceplate towards the chassis until it snaps into place.

Rear Fan Tray

To replace a rear fan tray, follow this procedure (see Figure 46 on page 165).

1. Loosen the eight self-contained screws that fasten the rear fan tray to the chassis.

2. Grasp the handles on each side of the fan tray and slowly pull the tray out of its bay until it is fully removed from the system.

3. Align the fan tray replacement within the chassis. The rear fan tray flanges in the chassis assure proper alignment within the bay.

4. Slowly slide the fan tray completely into its bay until its power connector mates with its corresponding midplane power connector. You should be able to see and hear the fans operating within the tray.

5. Manually fasten the eight self-contained screws of the rear fan tray to the chassis, then apply 4 in-lb of torque to each of the eight screws.

Figure 45: Front Fan Tray Replacement

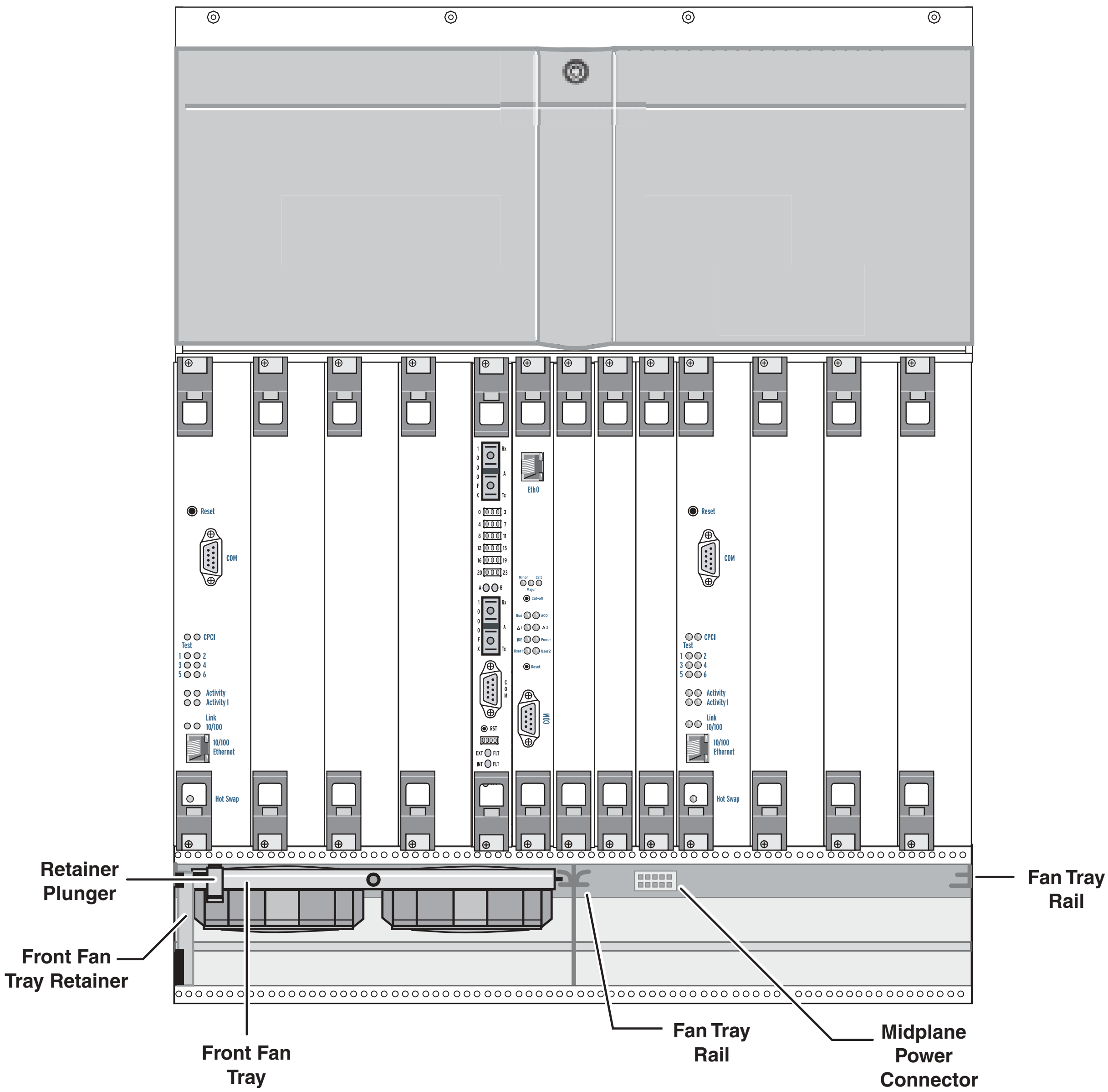
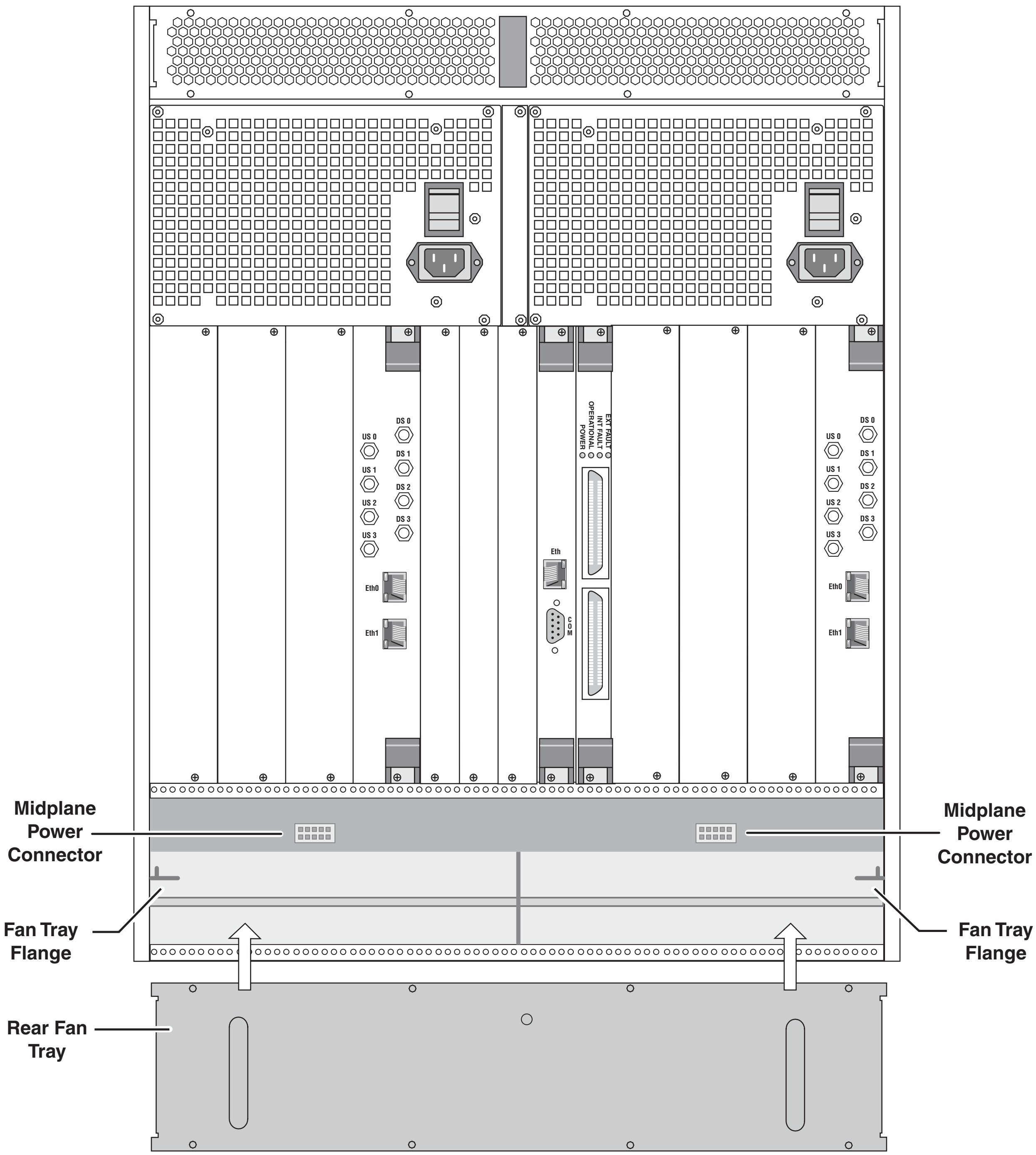


Figure 46: Rear Fan Tray Replacement



Module Removal

This section discussions the following procedures for card module removal:

- Remove a DOCSIS Module on page 166
- Remove an HFC Connector Module or SIM on page 168
- Remove a Chassis Control Module on page 169
- Remove a Hard Disk Module on page 170
- Remove a NIC Module on page 170
- Remove a NIC Access Module on page 170

Remove a DOCSIS Module

The DOCSIS Module is hot-swappable, so you can remove it or install it while the CMTS is powered on.

> **Note**
> If a DOCSIS Module is being hot-swapped, this procedure assumes you have moved all services supported by that module to another DOCSIS Module.

1. Loosen the two retainer screws.

2. Press upward and downward on the ejector releases (action #1 in Figure 47 on page 167), but do not pull on the ejectors until the blue Hot Swap LED on the faceplate is illuminated (see Figure 12 on page 30).

> **Note**
> One of the ejector releases on the DOCSIS Module activates a microswitch that signals the module to condition itself for hot-swapping.

3. After the Hot Swap LED is illuminated, simultaneously pull the ejectors away from the module faceplate. The ejectors should rest at approximately 45° from the faceplate. At this point, the module is physically and electrically removed from its connectors on the midplane.

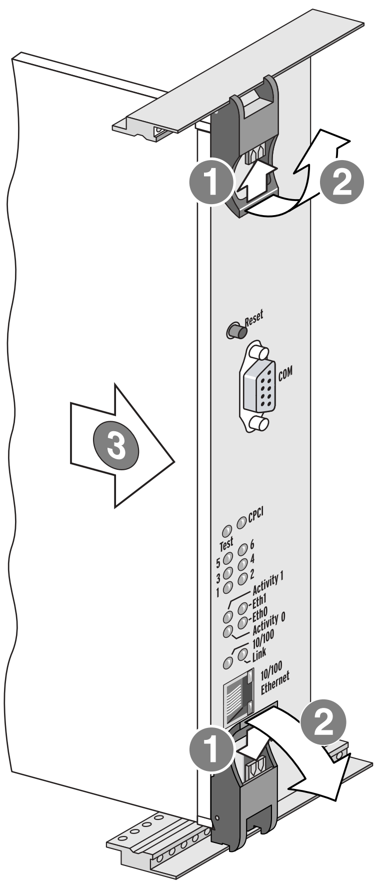
4. Slowly slide the module out of its slot until it is fully removed from the system.

5. Insert the module into an anti-static bag, being careful to avoid directly touching any component on the module. We recommend that you handle the module by its card edges or ejectors.

6. If the module will not be replaced, you must install an air management module in its place. Tighten the two retainer screws on the air management module by applying 3 in-lb of torque to each screw.

> **Caution**
>
> You must install air management modules and air management panels in all empty slots while operating the G10 CMTS to ensure that proper air ventilation occurs throughout the chassis, and to reduce EMI emissions.

Figure 47: DOCSIS Module Removal



Remove an HFC Connector Module or SIM

The HFC Connector Module and the SIM are hot-swappable, so you can remove them or install them while the CMTS is powered on.

1. Disconnect all cables that are attached to the module ports. If appropriate, tag each cable with its corresponding module port.

2. Loosen the two retainer screws.

3. Press upward and downward on the ejector releases (action #1 in Figure 48 on page 169).

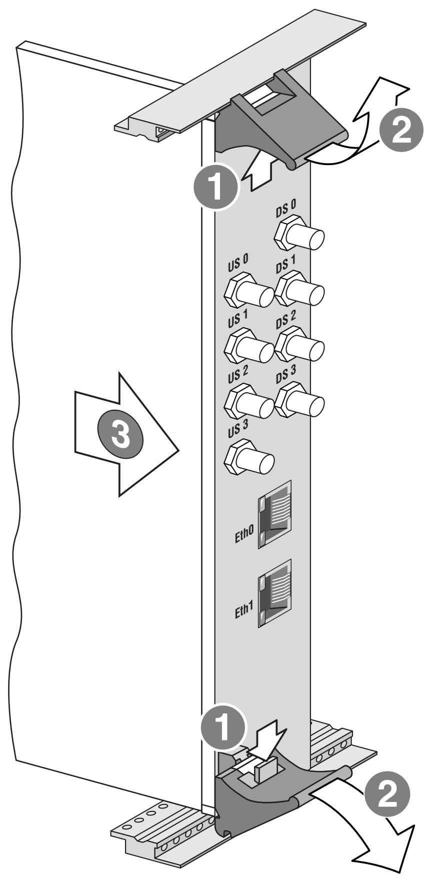
4. Simultaneously pull the ejectors away from the module faceplate. The ejectors should rest at approximately 45° from their locked position. At this point, the module is physically and electrically removed from its connectors on the midplane.

5. Slowly slide the module out of its slot until it is fully removed from the system.

6. Insert the module into an anti-static bag, being careful to avoid directly touching any component on the module. We recommend that you handle the module by its card edges or ejectors.

7. If the module will not be replaced, you must install an air management panel in its place. Tighten the two retainer screws on the air management panel by applying 3 in-lb of torque to each screw.

Figure 48: HFC Connector Module Removal



Remove a Chassis Control Module

The Chassis Control Module is hot-swappable. However, if you hot-swap the Chassis Control Module, all services supported by the CMTS are lost because the CMTS cannot operate without the Chassis Control Module.

To remove a Chassis Control Module, follow this procedure:

1. Stop the CMTS software by issuing the request system halt command:

   user@host> **request system halt**

2. Power down the CMTS.

3. Follow the same procedure described in “Remove a DOCSIS Module” on page 166.

Remove a Hard Disk Module

To remove a Hard Disk Module, follow this procedure:

1. Stop the CMTS software by issuing the request system halt command:

   user@host> **request system halt**

2. Power down the CMTS.

3. Follow the same procedure described in “Remove an HFC Connector Module or SIM” on page 168.

Remove a NIC Module

The NIC Module is hot-swappable, so you can remove it or install it while the CMTS is powered on. To remove a NIC Module, follow the same procedure described in “Remove a DOCSIS Module” on page 166.

Remove a NIC Access Module

The NIC Access Module is hot-swappable, so you can remove it or install it while the CMTS is powered on. To remove a NIC Access Module, follow the same procedure described in “Remove an HFC Connector Module or SIM” on page 168.

Part 4
Appendixes

Appendix A
Agency Certifications

This appendix lists agency compliance and certifications for the G10 CMTS.

Safety

- UL 60950 (US, Canada)

> **Warning**
>
> - This equipment is intended only for installation in a restricted access location within a building.
> - This equipment is intended for indoor use only.
> - This equipment does not have a direct copper connection to the outside plant.
> - Removal of power supplies or cards will result in access to hazardous energy.
> - Each power cord must be connected to an independent branch circuit.
> - Product connected to two power sources. Disconnect both power sources before servicing.

> **Caution**
>
> Risk of explosion if battery is replaced by an incorrect type. Dispose of used batteries according to the instructions.

- EN 60950 (Europe)

EMC

- FCC Part 15, Class A (US)

> **Note:** This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

- ICES–003, Class A (Canada)
- EN 55022, Class A (Europe)

Immunity

- EN 55024
- EN 61000–4–2 (ESD)
- EN 61000–4–3 (RF Field, AM)
- EN 61000–4–4 (EFT)
- EN 61000–4–5 (Surge)
- EN 61000–4–6 (RF Conducted Continuous)
- EN 61000–4–11 (Voltage Dips and Interrupts)
- EN 61000–3–3 (Flicker)

Appendix B
Radio Frequency (RF) Specifications

For reference purposes, Table 47 through Table 51 are reproduced from the CableLabs DOCSIS Radio Frequency Interface Specification, SP-RFI-I05-991105. For the complete DOCSIS specifications, see the appropriate CableLabs document.

This appendix contains the following tables:

Table 47: Downstream RF Channel Transmission Characteristics

Parameter	Value
Frequency range	Cable system normal downstream operating range is from 50 MHz to as high as 860 MHz. However, the values in this table apply only at frequencies > = 88 MHz.
RF channel spacing (design bandwidth)	6 MHz
Transit delay from headend to most distant customer	< = 0.800 msec (typically much less)
Carrier-to-noise ratio in a 6-MHz band (analog video level)	Not less than 35 dB[4]
Carrier-to-interference ratio for total power (discrete and broadband ingress signals)	Not less than 35 dB within the design bandwidth
Composite triple beat distortion for analog modulated carriers	Not greater than -50 dBc within the design bandwidth
Composite second order distortion for analog odulated carriers	Not greater than -50 dBc within the design bandwidth
Cross-modulation level	Not greater than -40 dBc within the design bandwidth
Amplitude ripple	0.5 dB within the design bandwidth
Group delay ripple in the spectrum occupied by the CMTS	75 ns within the design bandwidth
Micro-reflections bound for dominant echo	-10 dBc @ < = 0.5 m sec, -15 dBc @ < = 1.0 m sec -20 dBc @ < = 1.5 m sec, -30 dBc @ > 1.5 m sec
Carrier hum modulation	Not greater than -26 dBc (5%)
Burst noise	Not longer than 25 m sec at a 10 Hz average rate
Seasonal and diurnal signal level variation	8 dB
Signal level slope, 50-750 MHz	16 dB
Maximum analog video carrier level at the CM input, inclusive of above signal level variation	17 dBmV
Lowest analog video carrier level at the CM input, inclusive of above signal level variation	-5 dBmV

1. Transmission is from the headend combiner to the CM input at the customer location.
2. For measurements above the normal downstream operating frequency band (except hum), impairments are referenced to the highest-frequency NTSC carrier level.
3. For hum measurements above the normal downstream operating frequency band, a continuous-wave carrier is sent at the test frequency at the same level as the highest-frequency NTSC carrier.
4. This presumes that the digital carrier is operated at analog peak carrier level. When the digital carrier is operated below the analog peak carrier level, this C/N may be less.
5. Measurement methods defined in [NCTA] or [CableLabs2].

Table 48: Upstream RF Channel Transmission Characteristics

Parameter	Value
Frequency range	5 to 42 MHz edge to edge
Transit delay from the most distant CM to the nearest CM or CMTS	< = 0.800 msec (typically much less)
Carrier-to-noise ratio	Not less than 25 dB
Carrier-to-ingress power (the sum of discrete and broadband ingress signals) ratio	Not less than 25 dB[2]
Carrier- to-interference (the sum of noise, distortion, common-path distortion and cross-modulation) ratio	Not less than 25 dB
Carrier hum modulation	Not greater than -23 dBc (7.0%)
Burst noise	Not longer than 10 msec at a 1 kHz average rate for most cases[3,4,5]
Amplitude ripple	5-42 MHz: 0.5 dB/MHz
Group delay ripple	5-42 MHz: 200 ns/MHz
Micro-reflections -- single echo	-10 dBc @ < = 0.5 m sec -20 dBc @ < = 1.0 m sec -30 dBc @ > 1.0 m sec
Seasonal and diurnal signal level variation	Not greater than 8 dB min to max

1. Transmission is from the CM output at the customer location to the headend.
2. Ingress avoidance or tolerance techniques MAY be used to ensure operation in the presence of time-varying discrete ingress signals that could be as high as 0 dBc [CableLabs1].
3. Amplitude and frequency characteristics sufficiently strong to partially or wholly mask the data carrier.
4. CableLabs report containing distribution of return-path burst noise measurements and measurement method is forthcoming.
5. Impulse noise levels more prevalent at lower frequencies (< 15 MHz).

Table 49: Downstream RF Signal Output Characteristics

Parameter	Value
Center Frequency (fc)	91 to 857 MHz ± 30 kHz[1]
Level	Adjustable over the range 50 to 61 dBmV
Symbol Rate (nominal) 64QAM 256QAM	 5.056941 Msym/sec 5.360537 Msym/sec
Nominal Channel Spacing	6 MHz
Frequency response 64QAM 256QAM	 ~18% Square Root Raised Cosine shaping ~12% Square Root Raised Cosine shaping
Total Discrete Spurious Inband (fc ± 3 MHz) Inband Spurious and Noise (fc ± 3 MHz) Adjacent channel (fc ± 3.0 MHz) to (fc ± 3.75 MHz) Adjacent channel (fc ± 3.75 MHz) to (fc ± 9 MHz) Next adjacent channel (fc ± 9 MHz) to (fc ± 15 MHz) Other channels (47 MHz to 1,000 MHz)	< -57dBc < -48dBc; where channel spurious and noise includes all discrete spurious, noise, carrier leakage, clock lines, synthesizer products, and other undesired transmitter products. Noise within +/- 50kHz of the carrier is excluded. < -58 dBc in 750 kHz < -62 dBc, in 5.25 MHz, excluding up to 3 spurs, each of which must be <-60 dBc when measured in a 10 kHz band Less than the greater of -65 dBc or -12dBmV in 6MHz, excluding up to three discrete spurs. The total power in the spurs must be < -60dBc when each is measured with 10 kHz bandwidth. < -12dBmV in each 6 MHz channel, excluding up to three discrete spurs. The total power in the spurs must be < -60dBc when each is measured with 10kHz bandwidth.
Phase Noise	1 kHz - 10 kHz: -33dBc double sided noise power 10 kHz - 50 kHz: -51dBc double sided noise power 50 kHz - 3 MHz: -51dBc double sided noise power
Output Impedance	75 ohms
Output Return Loss	> 14 dB within an output channel up to 750 MHz; > 13 dB in an output channel above 750 MHz
Connector	F connector per [IPS-SP-406]

1. ±30 kHz includes an allowance of 25 kHz for the largest FCC frequency offset normally built into upconverters.

Table 50: DOCSIS Downstream Channel Rates and Spacing

Nominal Symbol Rate (Msym/sec)	Nominal Channel Spacing (kHz)	Bit Rate (bps)
5.056941 (64QAM)	6000	30,341,646
5.360537 (256QAM)	6000	42,884,296

Table 51: DOCSIS Maximum Upstream Channel Rates and Widths

Symbol Rate (ksym/sec)	Channel Width (kHz)[1]	Bit-rate/sec (QPSK)	Bit-rate/sec (16QAM)
160	200	320,000	640,000
320	400	640,000	1,280,000
640	800	1,280,000	2,560,000
1,280	1,600	2,560,000	5,120,000
2,560	3,200	5,120,000	10,240,000

1. Channel width is the -30 dB bandwidth.

Appendix C
EIA Channel Plans

Table 52 lists the EIA (Electronic Industries Association) standard, IRC (Incrementally Related Carrier), and HRC (Harmonically Related Carrier) frequency plans.

The frequencies in Table 52 represent the video center frequencies. Add 1.75 MHz to calculate the DOCSIS center frequency.

Table 52: EIA Channel Plan

Channel	STD	IRC	HRC
T-7	7.0000		
T-8	13.0000		
T-9	19.0000		
T-10	25.0000		
T-11	31.0000		
T-12	37.0000		
T-13	43.0000		
1 / A-8		73.2625	72.0036
2	55.2500	55.2625	54.0027
3	61.2500	61.2625	60.0030
4	67.2500	67.2625	66.0033
5 / A-7	77.2500	79.2625	78.0039
6 / A-6	83.2500	85.2625	84.0042
7	175.2500	175.2625	174.0087
8	181.2500	181.2625	180.0090
9	187.2500	187.2625	186.0093
10	193.2500	193.2625	192.0096
11	199.2500	199.2625	198.0099
12	205.2500	205.2625	204.0102
13	211.2500	211.2625	210.0105
14 / A	121.2625	121.2625	120.0060
15 / B	127.2625	127.2625	126.0063
16 / C	133.2625	133.2625	132.0066
17 / D	139.2500	139.2625	138.0069
18 / E	145.2500	145.2625	144.0072
19 / F	151.2500	151.2625	150.0075

Channel	STD	IRC	HRC
20 / G	157.2500	157.2625	156.0078
21 / H	163.2500	163.2625	162.0081
22 / I	169.2500	169.2625	168.0084
23 / J	217.2500	217.2625	216.0108
24 / K	223.2500	223.2625	222.0111
25 / L	229.2625	229.2625	228.0114
26 / M	235.2625	235.2625	234.0117
27 / N	241.2625	241.2625	240.0120
28 / O	247.2625	247.2625	246.0123
29 / P	253.2625	253.2625	252.0126
30 / Q	259.2625	259.2625	258.0129
31 / R	265.2625	265.2625	264.0132
32 / S	271.2625	271.2625	270.0135
33 / T	277.2625	277.2625	276.0138
34 / U	283.2625	283.2625	282.0141
35 / V	289.2625	289.2625	288.0144
36 / W	295.2625	295.2625	294.0147
37 / AA	301.2625	301.2625	300.0150
38 / BB	307.2625	307.2625	306.0153
39 / CC	313.2625	313.2625	312.0156
40 / DD	319.2625	319.2625	318.0159
41 / EE	325.2625	325.2625	324.0162
42 / FF	331.2750	331.2750	330.0165
43 / GG	337.2625	337.2625	336.0168
44 / HH	343.2625	343.2625	342.0171
45 / II	349.2625	349.2625	348.0174
46 / JJ	355.2625	355.2625	354.0177
47 / KK	361.2625	361.2625	360.0180
48 / LL	367.2625	367.2625	366.0183
49 / MM	373.2625	373.2625	372.0186
50 / NN	379.2625	379.2625	378.0189
51 / OO	385.2625	385.2625	384.0192
52 / PP	391.2625	391.2625	390.0195
53 / QQ	397.2625	397.2625	396.0198
54 / RR	403.2500	403.2625	402.0201
55 / SS	409.2500	409.2625	408.0204
56 / TT	415.2500	415.2625	414.0207
57 / UU	421.2500	421.2625	420.0210
58 / VV	427.2500	427.2625	426.0213
59 / WW	433.2500	433.2625	432.0216
60 / XX	439.2500	439.2625	438.0219
61 / YY	445.2500	445.2625	444.0222
62 / ZZ	451.2500	451.2625	450.0225

Channel	STD	IRC	HRC
63 / AAA	457.2500	457.2625	456.0228
64 / BBB	463.2500	463.2625	462.0231
65 / CCC	469.2500	469.2625	468.0234
66 / DDD	475.2500	475.2625	474.0237
67 / EEE	481.2500	481.2625	480.0240
68 / FFF	487.2500	487.2625	486.0243
69 / GGG	493.2500	493.2625	492.0246
70 / HHH	499.2500	499.2625	498.0249
71 / III	505.2500	505.2625	504.0252
72 / JJJ	511.2500	511.2625	510.0255
73 / KKK	517.2500	517.2625	516.0258
74 / LLL	523.2500	523.2625	522.0261
75 / MMM	529.2500	529.2625	528.0264
76 / NNN	535.2500	535.2625	534.0267
77 / OOO	541.2500	541.2625	540.0270
78 / PPP	547.2500	547.2625	546.0273
79 / QQQ	553.2500	553.2625	552.0276
80 / RRR	559.2500	559.2625	558.0279
81 / SSS	565.2500	565.2625	564.0282
82 / TTT	571.2500	571.2625	570.0285
83 / UUU	577.2500	577.2625	576.0288
84 / VVV	583.2500	583.2625	582.0291
85 / WWW	589.2500	589.2625	588.0294
86 / XXX	595.2500	595.2625	594.0297
87 / YYY	601.2500	601.2625	600.0300
88 / ZZZ	607.2500	607.2625	606.0303
89	613.2500	613.2625	612.0306
90	619.2500	619.2625	618.0309
91	625.2500	625.2625	624.0312
92	631.2500	631.2625	630.0315
93	637.2500	637.2625	636.0318
94	643.2500	643.2625	642.0321
95 / A-5	91.2500	91.2625	90.0045
96 / A-4	97.2500	97.2625	96.0048
97 / A-3	103.2500	103.2625	102.0051
98 / A-2	109.2750	109.2750	108.0054
99 / A-1	115.2750	115.2750	114.0057
100	649.2500	649.2625	648.0324
101	655.2500	655.2625	654.0327
102	661.2500	661.2625	660.0330
103	667.2500	667.2625	666.0333
104	673.2500	673.2625	672.0336
105	679.2500	679.2625	678.0339

Channel	STD	IRC	HRC
106	685.2500	685.2625	684.0342
107	691.2500	691.2625	690.0345
108	697.2500	697.2625	696.0348
109	703.2500	703.2625	702.0351
110	709.2500	709.2625	708.0354
111	715.2500	715.2625	714.0357
112	721.2500	721.2625	720.0360
113	727.2500	727.2625	726.0363
114	733.2500	733.2625	732.0366
115	739.2500	739.2625	738.0369
116	745.2500	745.2625	744.0372
117	751.2500	751.2625	750.0375
118	757.2500	757.2625	756.0378
119	763.2500	763.2625	762.0381
120	769.2500	769.2625	768.0384
121	775.2500	775.2625	774.0387
122	781.2500	781.2625	780.0390
123	787.2500	787.2625	786.0393
124	793.2500	793.2625	792.0396
125	799.2500	799.2625	798.0399
126	805.2500	805.2625	804.0402
127	811.2500	811.2625	810.0405
128	817.2500	817.2625	816.0408
129	823.2500	823.2625	822.0411
130	829.2500	829.2625	828.0414
131	835.2500	835.2625	834.0417
132	841.2500	841.2625	840.0420
133	847.2500	847.2625	846.0423
134	853.2500	853.2625	852.0426
135	859.2500	859.2625	858.0429
136	865.2500	865.2625	864.0432
137	871.2500	871.2625	870.0435
138	877.2500	877.2625	876.0438
139	883.2500	883.2625	882.0441
140	889.2500	889.2625	888.0444
141	895.2500	895.2625	894.0447
142	901.2500	901.2625	900.0450
143	907.2500	907.2625	906.0453
144	913.2500	913.2625	912.0456
145	919.2500	919.2625	918.0459
146	925.2500	925.2625	924.0462
147	931.2500	931.2625	930.0465
148	937.2500	937.2625	936.0468

Channel	STD	IRC	HRC
149	943.2500	943.2625	942.0471
150	949.2500	949.2625	948.0474
151	955.2500	955.2625	954.0477
152	961.2500	961.2625	960.0480
153	967.2500	967.2625	966.0483
154	973.2500	973.2625	972.0486
155	979.2500	979.2625	978.0489
156	985.2500	985.2625	984.0492
157	991.2500	991.2625	990.0495
158	997.2500	997.2625	996.0498
159	1003.250	1003.2625	1002.0501

Part 5
Index

Index

Numerics

A

B

C

V